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ORIGINAL ARTICLES

THE GROWTH OF BONE AS RELATED TO FUNCTION*

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IN RELATING form to function the *extrinsic* factor only can be studied in experiments and its influence seen in the treatment of patients. But the intrinsic factor should not be entirely forgotten.

The *intrinsic* factor is laid down by the function that the organ has performed for thousands of years during the life of our ancestors. Only those qualities which are of advantage to normal functional acts are transmitted, and we inherit a latent endeavor of our jaws to develop in the way they will be most useful to us. Every treatment which tries to establish the optimal jaw-form is greatly helped by this inner power.

The extrinsic factor of function produces growth and development through the influence of the trophic nerves. The particular structure of the bone makes these changes possible.

The structural elements are the *trabeculae* which change in size and in number under the influence of function. The *compact* and *cancellous* part of the jaw bones are equally liable to changes, as their structure is the same and no boundary line can be drawn between them (Fig. 1). In the compact bone the trabeculae are thick and Haversian canals small. Toward the center of the bone the trabeculae become gradually thinner, and the canals widen until they are called marrow spaces.

Under heavy function, the trabecular structure in the cortical and cancellous parts of the jaw becomes denser. A case of *unilateral mastication* affords a good example for these changes: the right side of a mandible has been without occlusion, according to the outline of the cusps (Fig. 2). The left side was under heavy masticatory stress and the cusps are worn down (Fig. 3). The

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development of bone on this side is stronger, the trabeculae are thicker and more numerous. The cancellous parts show the difference and also the cortical plates in the gingival region, in the apical region, and on the lower border of the mandible (Fig. 4).

Other examples of the influence of function upon the growth of bone can be seen in the condition of the alveolar process in *malpositions* of the teeth.

The tooth is *suspended* in the alveolus by the fibers of the peridental membrane. The stress of normal mastication is transmitted to the bone by means of the fibers which exert a *pull* upon the bone. This pull in the course of normal function is the physiologic stimulus to the alveolar bone.

The main force of mastication is directed toward the long axis of the tooth. The stress is equally received by all the fibers and equally distributed to all

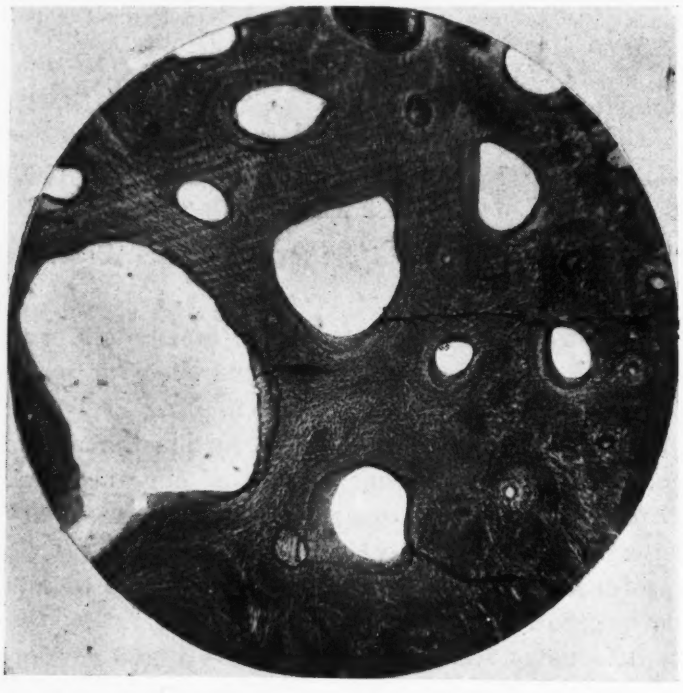

Fig. 1.—Gradual transition from compact bone to cancellous bone.

the bony walls of the alveolus. One part of the masticating force, as well as other forces of occlusion, the pressure of lips, cheeks, and tongue, stress the tooth in other directions than in its long axis. But all these forces are normally balanced in such a way that they furnish a stimulus of about the same intensity in every direction, which means that a stress in a *labial* direction is compensated by one in a *lingual* direction, one in a mesial by another in a distal direction (Fig. 5).

As a consequence of this arrangement, we again find the fibers of *every part* of the peridental membrane in function, and through the agency of the fibers the bone in function. A force in a *labial direction* stretches fibers on the *lingual* side and places the bone on the *lingual* wall under function. A force in a lingual direction stretches the labial fibers, and the bone of the labial wall is placed under function.

In other words, the tooth is supported against displacement in a labial direction by the bone on the lingual side, and against displacement in a lingual direction by the bone on the labial side. An appliance producing mesial movement of the tooth meets resistance not from the bone on the mesial side primarily, but from the bone on the distal side, to which the tooth is fastened by the fibers.

In some cases, however, the tooth acts like a *lever*, the fulcrum being at about the middle of the root. In forces pressing lingually the tooth does not

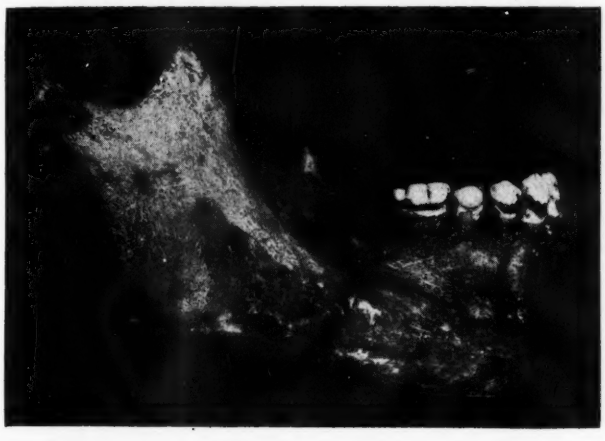

Fig. 2.—Side without occlusion as seen from outline of cusps.

Fig. 3.—Cusps worn down under unilateral mastication.

move at all in the middle third, while the gingival third is pressed lingually and the apical third is pressed labially. Translating this movement in the language of fiber-pull and bone-function it means that on the labial side the gingival third of the peridental fibers is stretched, the bone in this part supporting the tooth, while in the apical third the membrane on the labial side is slightly compressed and no force is exerted upon the bone. On the lingual side the gingival third of the fibers is compressed and the apical third stretched, the bone here preventing a dislocation of the root.

While this action occurs in every application of force which is not in

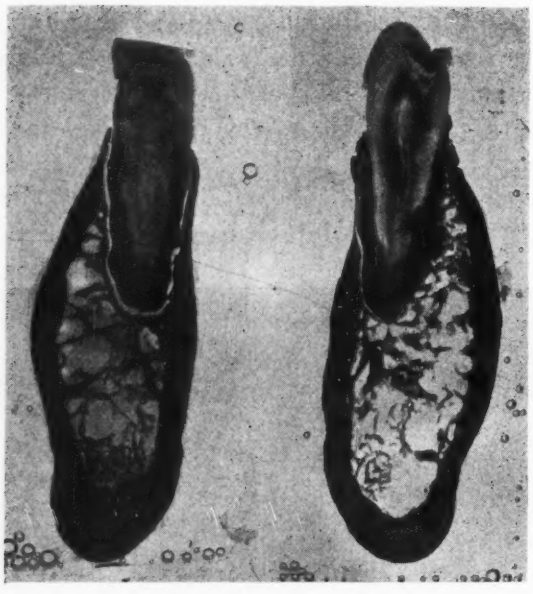

Fig. 4.—Section through molars of mandible with unilateral mastication.

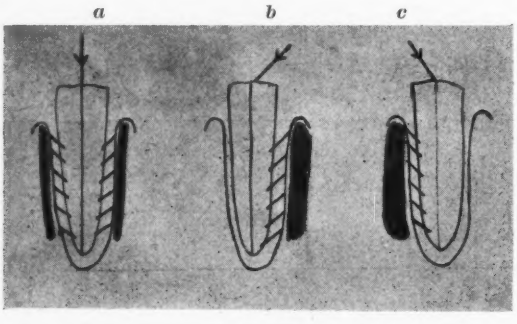

Fig. 5.—Tooth in normal inclinations, functional stimuli equally distributed.
a. Force acting in the direction of the long axis.
b. Force acting from the lingual.
c. Force acting from the buccal.
Black area signifies bone under function.

Fig. 6.—Heavy bone in regions of pull, lingual side of anterior part of incisor and buccal side of posterior part.

the direction of the long axis of the tooth, and is not a bodily tooth movement, it is clearly seen only in forces which are strong and exerted under a pronounced angle.

The incisor of a rodent is a long tooth, which receives the force in a direction almost perpendicular to its long axis, and shows the strong development of bone at the *regions* of *fiber-pull.* These places are the lingual wall of the alveolus in the anterior part and the buccal wall in the posterior part of the alveolus (Fig. 6).

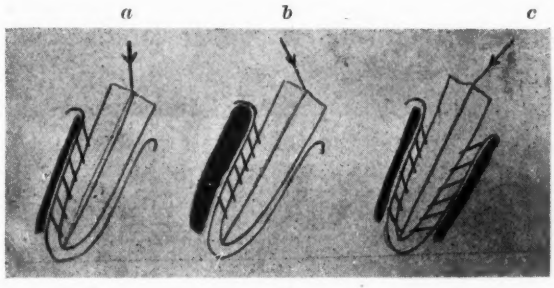

Fig. 7.—Tooth in abnormal lingual inclination, stimuli applied mainly to buccal side.
a. Vertical force.
b. Force acting from the buccal.
c. Force acting from the lingual.
Black area signifies bone under function.

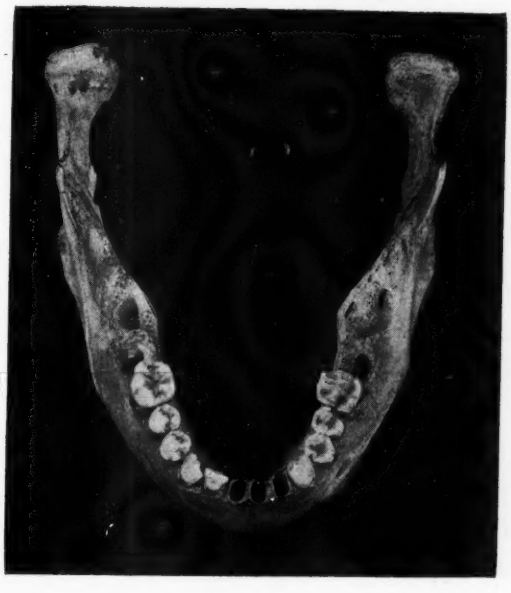

Fig. 8.—Alveolus of third left molar showing abnormal lingual inclination of tooth.

We have to consider those facts carefully when we apply them to the conditions of *malposed teeth.*

The malposed tooth does not receive the greatest amount of stress in the direction of its long axis. Also the other forces of occlusion are *not balanced.* As a result, the stresses are not equally distributed to the alveolar process, but one side invariably receives most of the stress and most of the functional stimuli and the other receives but little (Fig. 7).

In abnormal labial inclinations the forces of occlusion concentrate toward the labial side and tend to increase the inclination. In lingual inclinations they concentrate toward the lingual side.

A mandibular molar in *lingual* inclination receives hardly any force in the direction of its long axis. The straight masticatory force from the maxillary teeth tends to press it *lingually*. The lateral masticating excursions and the other forces of occlusion point with their long power vectors *lingually* (Fig. 8).

The lingual plate of bone does not function. There is hardly any stimulus —some possibly from the tongue—to stress the tooth in a buccal direction and stretch the fibers on the lingual side. The bone here is weak and shows absorptions (Fig. 9).

The support for the molar comes from the *buccal* plate of the alveolus. Here are the fibers that suspend the tooth and prevent its further lingual tip-

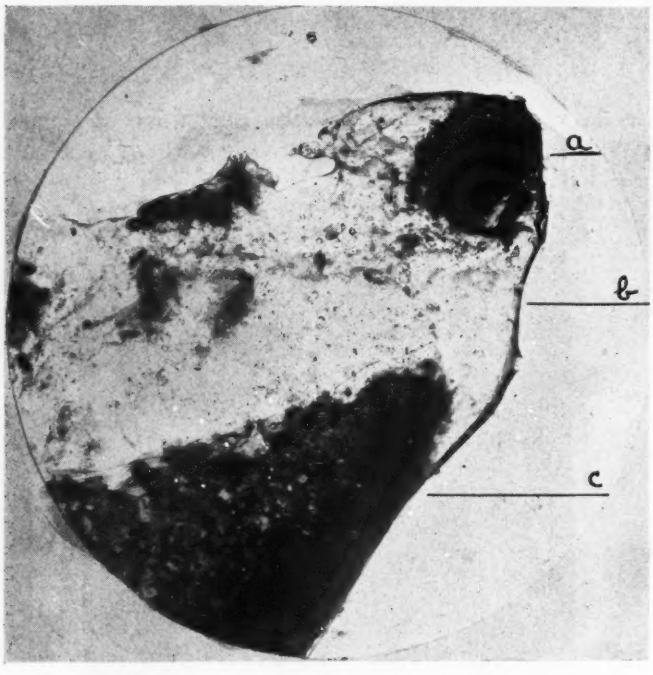

Fig. 9.—Lingual wall of alveolus, absorption caused by abnormal lingual inclination of tooth.

a. Tip of alveolar wall.
b. Area of absorption.
c. Lower part of alveolus.

ping. The bone of the buccal wall is therefore well functioning and is strongly developed (Fig. 10).

It is a fascinating idea to believe that it is the *lingual* wall that supports the tooth which is actually lying on it. It is an idea taken from our daily experience, for we are accustomed to see nearly all the objects around us supported from below and pressing against their plane of support. But it is a wrong idea if applied to the tooth, peridental membrane, and alveolar bone. The tooth is *suspended* in its socket.

The example of the molar in lingual inclination can be modified and other teeth and other inclinations examined. In *lingual* inclinations it is always the

buccal plate, in *buccal* inclinations the *lingual* plate that is strong, provided that other conditions are normal.

Fig. 11 shows incisors in lingual inclination. The bone on the buccal side is much stronger than on the lingual, the cementum thicker, and the peridental fibers longer, due to the heavier function of the structures on this side (Fig. 12).

Thus we see that a certain amount of stress in *every direction* is necessary to insure the proper development of the alveolar bone on each side of the tooth.

Under the influence of these stresses the tooth makes a small *movement* until the fibers of the peridental membrane are stretched, cementum and bone giving support and at the same time receiving their functional stimulus.

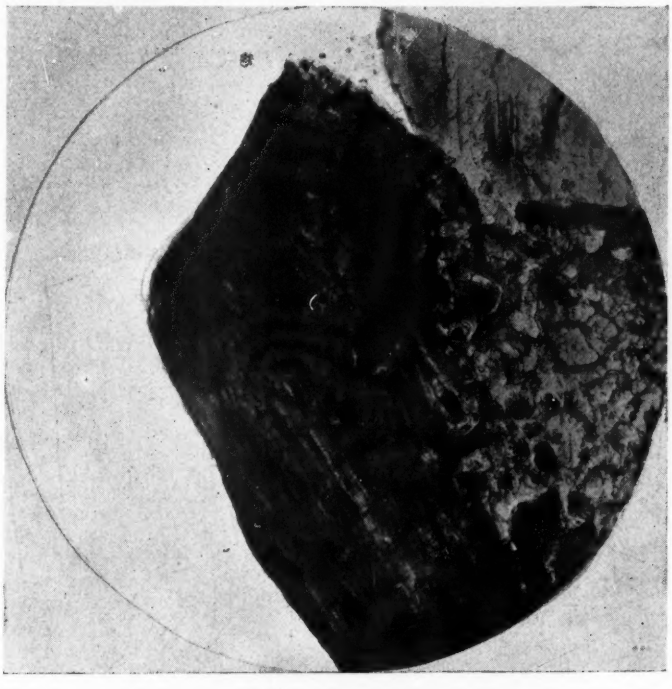

Fig. 10.—Buccal wall of alveolus, strong development due to abnormal lingual inclination of tooth.

The small movements of the tooth in its alveolus under the influence of stresses constitute the *physiologic mobility* of the tooth. The normal development of the bone is dependent upon this mobility.

Abnormal inclinations are only *one cause* preventing physiologic mobility. Normal occlusion is dependent upon the proper characteristics of the occlusal surfaces, the contact with the approximating teeth, and the muscular pressure of lip, cheek, and tongue. Normal mobility is dependent upon quite the same conditions. Every disturbance of them effects the alveolar bone.

If a tooth lacks its mobility in *one direction,* the effect can be seen in the weak development of the alveolar process on the *opposite side.*

The left canine of Fig. 13 has an abnormal contact with the left lateral incisor and through the *abnormal contact* it loses its physiologic mobility in the

lingual direction. While forces in the buccal direction can act freely upon the tooth, forces in the lingual direction meet with the resistance of two teeth instead of one.

The physiologic mobility is disturbed in this case not because the forces are unbalanced, but because the force in the lingual direction does not result

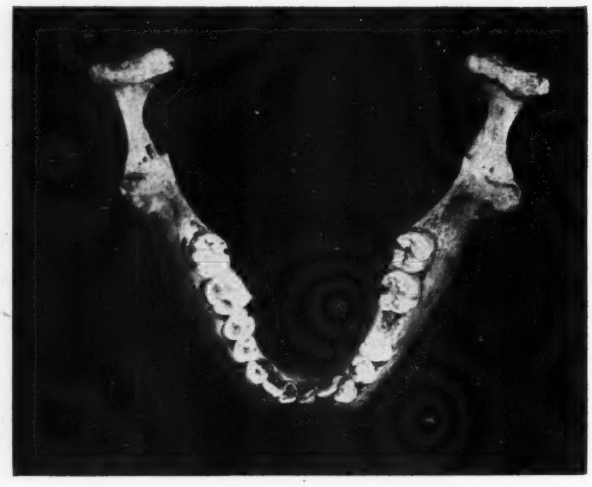

Fig. 11.—Incisors in abnormal lingual inclination.

Fig. 12.—Section of left lateral incisor, peridental unit better developed on buccal side due to abnormal lingual inclination of tooth.

in normal mobility. The buccal wall of the alveolar process does not function and is little developed (Fig. 14).

The extreme weakness of the alveolar process on the side on which the mobility of a tooth is insufficient—as in abnormal inclinations or in crowding of

teeth—suggests itself as one more reason why malpositions should be corrected, even if limited to an individual tooth. For such teeth are subject to pyorrhetic diseases.

Fig. 13.—Left canine prevented from physiologic mobility by abnormal contact with lateral incisor.

Fig. 14.—Section of canine, poor development of buccal plate due to disturbed mobility in lingual direction.

The first signs of disturbed mobility are a thinning of the alveolar plate and radiolucency of the crest. Then follows a lowering of the crest and complete absorption of the bone on the affected side.

The normal tooth *must move* in its alveolus. Lack of mastication, malposi-

tions, or other causes preventing this movement are sources of disease. Normal conditions of the alveolar process are dependent upon mobility.

From the problem: function and *growth*, develops the problem: function and *health*.

I have to express my gratitude to Dr. Martin Dewey in whose laboratory the sections were made. He assisted me with his advice to such a degree that the credit for this work belongs more to him than to myself.

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RECENT CONTRIBUTIONS TO OUR KNOWLEDGE OF BONE AND TOOTH CALCIFICATION*

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IT IS a pleasure to have the opportunity to present some results of an elementary study of calcification and to point out a few of the several important contributions recently made to this field. Those practical questions suggested by your experience and which you may hope to have answered will be avoided. In their stead a more fundamental and essential aspect will be brought to your attention.

Whether one studies the formation of calcareous masses in dying tissues, in diseased or inflamed organs, or accompanying the transformation of cartilage into bone; whether one studies the calcification in the sea, the soil, or the body, there stand out certain factors which are essential to a very general process, the formation of a solid in a fluid or semifluid mass. The rôle of calcium in the living body has been brought to our attention in many ways. Its significance is well recognized in therapy, in the activity of the endocrine glands, in the tonicity of cells and tissues, and in ossification. But the manner in which it combines with phosphorus and is subsequently precipitated and associated with organic material as in bone is still a mystery. We are not yet informed as to the condition in which the calcium salts exist in bones and teeth. The more common solids of calcium are crystalline aggregates; but we are not yet aware whether crystallization is an active process in osteogenesis. It is in the hope that we may throw some light upon the early stages of ossification and with particular interest in the crystal phase that we have undertaken work in this field.

The general plan of our work involves the acceptance of certain ideas, which will be briefly discussed in this paper, but which will undoubtedly need reconsideration as scientific work is carried to new levels. It is presumed that since calcium and phosphorus exist in bone in quite definite proportions that a molecular configuration of some significance follows the usual chemical reactions. We know that a calcium phosphate exists in bone and teeth but are not yet certain of its true form nor its rôle in living bone. The older idea was that at first an organic-carbonophosphate was formed by living cells. Our present conception is that instead of this combination arising by cell metabolism the calcium phosphate is formed in solutions which are outside of the cell, solutions which are supersaturated with calcium and phosphate ions. In the intercellular fluids the phosphates arise as finely divided crystals which become associated with the organic matrix, passing through a gelatinous and semisolid stage into a hardening mass. Studies of how the crystal structures

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come to be associated with various masses in the living tissues and how they are related to the hardening of bone are thus contemplated. Our work first of all is of a qualitative nature. Measurements of the related reactions which are involved in the functional condition will be undertaken subsequently. Such is an attempt to study bone from the systematic and from the physiologic, in some contrast to the structural or histologic point of view.

In professional and unreflective labors the inherent strength of the scientific method is often unappreciated. Too often are we given to "trying anything!" In consequence, we find that such an empirical approach, rarely brings permanent results. This point is made here, not to discourage empirical work as a whole, for well-planned investigations are of unquestionable value; but dentistry has at the present time an accumulated mass of miscellaneous experimental data much of which is confusing and of little value. Recognizing this it is our aim to re-search reliable channels, to take into consideration some essential and fundamental matters, and not rely wholly upon chance for the attainment of results. How many of you would build today an arch with which you were to work without considering the basic elements, tensile strength of the materials, sound proportions, and good design? Similarly, to attack the problem of "retention" as you must ultimately do, the significant fundamental elements upon which depend the resorption of bone and the necessary deposition of calcium salts must be brought into view. The disturbing matters on the surface in orthodontia today have a deeper meaning than may be at first visaged. I am not able to answer practical orthodontic questions because I am uninformed on such matters. I can, however, present some important points from related fields which you may utilize; or I may go deeper than your immediate problems and provide an answer to several questions. The present information concerning bone growth and repair with all the published articles on pressure stimulation, endocrine function, calcium metabolism, ultraviolet therapy, is like a raft of empirical findings on a turbulent ocean, seasickening to those partaking in the ups and downs, and tending to scatter any crew which may have shipped aboard. Some of the crew may float, others may call for aid and pour oil on the troubled waters, while still others may be submerged, apparently lost, but in reality are below searching for more essential factors and causes.

As I look at the growth and decay of bone and tooth substance, we are possessed of an elaborate mental superstructure concerning the subject and upon which orthodontic practices have been built. There is a weakness in the foundation, arches without keystones, undermining springs below the piers. We must ascertain how the chief characteristics of bone and teeth depend upon the essential elements which enter into the mass. Are the characteristics of bone dependent upon the form of the calcium salts in the mass or not? Is there a dependency upon the association of these with the matrix?

BONE GROWTH, AN EXAMPLE OF CALCIFICATION

Ossification as we shall consider it depends upon (1) the formation of certain salts of calcium and (2) their conversion or association with other substances to form a solid mass. The precipitation and deposition of calcium

salts are not processes confined to bones. Tissues of mesodermal, endodermal and epidermal origin are known to calcify and to become quite rigid. Lime skeletons furthermore are widely distributed among both animals and encasements of calcium as well as other important structures occur in plants. Besides the relation to calcium there are similarities in these various structures which permit them to be considered under one head and to be investigated as one general process including special cases. Certainly the development of the cementum, dentine and bone are chemically and biologically similar and there are not great chemical or biologic differences between enamel and shells. It thus is practical to study ossification, as well as amelification, as related cases of a general process, calcification.

Chief among the elements which enter into the first stage of the process are the chemical substances, calcium, phosphorus, and carbon. Although less in quantity the elements sodium, potassium and magnesium have been found to affect the precipitation of the calcium salts. Finally two other chemical entities which arise from water are important to consider since they affect the type of phosphate which is formed. They are the hydrogen and hydroxyl ions.

The reactions of calcium with other substances have for some time been studied in pure solutions chiefly to determine the solubility of the salts. A sufficiently clear explanation of calcification has not been achieved, however, through this work. The reactions are of a different order in the mixed solutions of the living tissues. The solubility of the calcium salts in body fluids like blood serum, lymph, etc., has a more important relation to our problem and reactions which occur in these fluids may be studied with greater hope of return in the knowledge of the behavior of the insoluble compounds of calcium as related to calcification in living tissues.

Although less is known about the matter, comment may be made concerning the transformation of the calcium salts during the hardening and setting processes in bone. It is possible that a precipitate of the calcium salts, either as phosphate or mixtures of calcium phosphates and bicarbonates, is deposited in a gelatinous mass, the organic matrix. In such a case we would expect to find masses of calcium salts much as would be found in nature. But we are not aware of typical crystalline or rock-like growths in the tissues which undergo calcification. The manner in which the precipitated calcium salts become associated with the organic matrix or are invested within the matrix remains to be studied. The physical and chemical processes which underlie the solidification of bone have yet to be made clear. One may consider the solidification of alloys, or water, with a sharp lowering in the temperature as an example of crystallization with subsequent hardening or setting. The freezing-out of ice from a cooled mixture of salt and water is another example of crystallization in liquids. But these illustrations are greatly different from the apparent crystallization and setting in bone. In a sense the formation of crystals through evaporation or other removal of the solvent is more typical of the calcification in which we are interested. An example of the crystallization through concentration of the dissolved mass is that of alum. Evaporation of the water from an alum solution, or its removal

by alcohol will so concentrate the liquid with alum that crystallization can be easily induced. It happens that the liquid may be very saturated or supersaturated as it may be spoken of and crystallization must be induced by inoculation with a crystal of alum. The liquid mass is thereafter promptly converted into one chiefly consisting of crystals closely packed, but of quite rigid consistency. Of course in calcification the water is not removed as just described in the alum solution. The concentration is effected by larger and larger quantities of the calcium phosphate being formed in the intercellular fluid, as though it were being held in check. The tendency toward a separation of the solid calcium phosphate as finely divided particles or crystals occurs when saturation is advanced. One may observe flocculation and precipitations of calcium phosphate by adding lime water to a solution of phosphoric acid, until there exist two equivalents of calcium to one of phosphorus. Continued shaking of this liquid will finally produce a constant mass of tricalcium phosphate as a finely divided solid which has been precipitated out of the solution and now remains in contact with the liquid. But this precipitate never becomes hard and does not undergo a setting. The precipitation of the calcium phosphate into a gel is presumably a step necessary to effect solidification.

Calcification as we know it to occur in bones, teeth, and shells is more than a precipitation process, however this may occur. Analyses of calcified tissues indicate the presence of organic matter in varying proportions. A solid appears to be formed by the association of the precipitated calcium salt with some liquid which contributes to a solidifying mass, as though there were a combination between the gel and the calcium salts which then sets and hardens. It is much as if we added a cement to water.

Oxyphosphates and oxychlorides of various metals pass through a gelatinous state and then set very rigidly. Plaster of Paris probably passes through the gel stage, becomes hydrated, and is involved with crystals to form a closely felted mass. In the case of rubber, which arises by various processes from the milk-like plant "latex," it is first a solution or "sol" protected by a protein. With the taking of sulphur into the mass and vulcanization it sets into a semisolid mass, a condition which may also be effected by exposure to acids even without sulphur. Various uric acid salts pass through a jelly stage, and become more rigid with the appearance of crystals in the mass. Although not informed as to the method or processes of solidification in bone the stages subsequent to initial crystallization or precipitation of the finely divided calcium phosphate suggest a hardening process as the results of combination of the calcium salt or salts with the cartilage or similar matrix.

INITIATION OF CALCIFICATION

It is generally considered that in a solution of calcium phosphate there may arise (1) dissociated calcium (written as Ca^{++}) and phosphate (PO_4^{---}), (2) dissolved but undissociated calcium phosphate and (3) solid, undissolved calcium phosphate in the form of the precipitate. This condition may be expressed as follows:

$$\underset{\text{dissociated}}{3(Ca^{++}) + 2(PO_4^{---})} \leftrightarrows \underset{\text{undissociated}}{Ca_3(PO_4)_2} \leftrightarrows \underset{\text{solid}}{Ca_3(PO_4)_2}$$

Recent contributions to our knowledge regarding calcium phosphates in pure solutions and body fluids[1, 2, 3] may help to explain the condition which exists at the time of precipitation of the finely divided solid. It is not completely stating the case to say that the calcium phosphate in solution is undissociated and tends to become an undissociated salt or to finally precipitate as a solid phosphate. As a matter of fact there is at the same time the undissociated and dissociated, the solid and the dissolved states coexisting. If more calcium is added to the mass more tends to be precipitated; if calcium is removed from the solution some of the solid tends to be redissolved. In other words a balance tends to exist and the changes pass from one stage to another when the balance is upset ever so slightly. The reactions written above actually pass in both directions and the balance exists when the rates in these two directions are the same.

But we are not certain that the chemical analyses have given us a correct picture of the calcium phosphate and hence the above statement is open to correction. Bassett[4] points out that the calcium phosphate of bone is slightly different from the tricalcium phosphate we have presumed. A study of the forms of calcium phosphate which exist under the conditions that bone salts exist suggests an association of the tricalcium phosphate with lime, viz., $[CA_3(PO_4)_2]_3.Ca(H)_2$. The latter form, known as oxyapatite is more stable than the former tricalcium phosphate. In addition to the calcium and phosphate ions there are also essential to the formation of the bone salts the dissociated elements of water which are present and greatly affect the chemical reactions. In fact the elements from water have some considerable part to play in the acidity of the fluids where the calcium salts arise, as in other chemical and biologic reactions.

The initiation of calcification occurs, then, in the presence of several factors, which may vary among themselves and provide not one but several chemical entities, in manners which we speak of as reversible.

As has been indicated in the precipitation of calcium phosphate the addition of water to the solution or the removal of some of the dissolved phosphate will cause the solid precipitate to go into solution, that is, to affect the balance which previously existed and to establish a new condition of equilibrium. Any alteration in the dissolved elements of the intercellular fluids affecting the calcium and phosphate ions alters this balance. The condition is one which is under tension and if affected by local change may move in one or another of two possible directions. Calcification may be considered as an example of a reversible process. The intercellular fluids, in the tissue spaces, behave as if they were supersaturated with calcium phosphate and are intermediate between the solid bone and more dilute body fluids. We presume that the body fluids are separated from the bone-forming mass, circulating in vessels through those regions where calcification is in progress. The solid bone is in direct contact with the supersaturated fluids. But changes in the body fluids may affect the calcium and phosphate in the

intercellular fluids and the bones in a reciprocal relation. Slight changes in one stage of the process may throw the direction from calcification to one of decalcification.

Reversible processes are not new to you and need not be greatly elaborated to make it clear that bone stands in a sort of unstable relation with the blood and lymph supply. The setting of gelatin on cooling and the liquefaction on heating is a reversible reaction, in that one physical state may be transformed into another without any chemical change. Many colloids and colloidal aggregations may change from solid to liquid and from the liquid back to solid without chemical alteration or disintegration. Crystals of ice act similarly. It is conceivable that a supersaturated solution of alum may be changed by so slight an amount as to form a few crystals and when transferred to a more moist region to dissolve the crystals recently formed. The calcification process may be similarly affected if we draw upon the bones or the intercellular fluids of the bone-forming zones for our calcium or phosphorus supply. If the level is slightly lowered in the general body fluids, or the calcium is eliminated faster than it is taken in some of the solid must dissolve to make up for the deficiency. As the calcium tide is raised outside of the bone-forming zone the precipitation and solidification process goes on.

Alterations in the carbon dioxide concentration of the intercellular fluids, in the colloids, and in the magnesium and other mineral ingredients affect the change from solid into liquid and back. In the saliva removal of the carbon dioxide can to some extent cause precipitation of the inorganic content. Addition of the carbon dioxide will cause resolution of the precipitated mass.

The acidity, whether from foreign acids or from salts, may likewise affect the solid and liquid state in a reversible manner. If we look at water as comprised of hydrogen, which we write in this connection as (H^+), and hydroxyl (OH^-), that is

$$H_2O = HOH = H^+ + OH^-$$

we will find the same elements which are so effective in the states of neutrality, alkalinity and acidity. Hydrochloric acid is written

$$HCl = H^+ + Cl^-$$

and caustic soda may be written as

$$NaOH \pm Na^+ + OH^-$$

and when these elements react to form sodium chloride

$$HCl + NaOH = H^+ + OH^- + Na^+ + Cl^- = H_2O + NaCl$$

the ions may reform into salt and water. If there is an equal amount of H^+ and OH^- neutrality exists, just as when an equal amount of acid and alkali exist neutrality is established. When there is an excess of H^+ an acid condition is effected, and with excess of OH^- alkalinity results. In the usual condition water is neutral, that is, not an acid or alkali. The hydrogen and hydroxyl ions are known to exist in equal amounts as is indicated by

$$(H^+) = 0.000\ 000\ 1\ N = (OH^-)$$

In this case the normal concentration of hydrogen ions, the amount in a liter of water, is equal to the hydroxyl. The amount is small, about one ten millionth gram of the electrically charged masses in the liter. When hydrogen is greater than hydroxyl, that is,

$$(H)^+ > 0.000\ 000\ 1\ N > (OH)^-$$

then the solution is spoken of as acid in reaction; and if the hydrogen is less than the hydroxyl, that is,

$$(H)^+ < 0.000\ 000\ 1\ N < (OH)^-$$

the solution is alkaline. If carbon dioxide is added to water whereby carbonic acid is formed we have an excess of hydrogen ions and a condition, indicated as follows:

$$H_2O + CO_2 = H_2CO_3 = H^+ + HCO_3^-$$

The hydrogen ion and the bicarbonate ion are here active and will combine in no uncertain terms with calcium phosphate to form bicarbonates of calcium. Hence either the hydrogen ion or the hydroxyl ion whether from one source or another may upset the balance existing between the precipitate of a calcium phosphate solution and the phosphate in solution. In general, excess of the hydrogen ions tends toward solubility of bone salts, and hydroxyl tends toward precipitation.

The body fluids like blood are not very highly concentrated in salts, except perhaps in sodium chloride, and are usually only slightly alkaline. We may speak of them as dilute solutions, bordering on neutrality. Should we try to change the nearly neutral condition with acids we would be surprised at the tenacity with which the fluids maintain their original reaction. They appear to be in a state of resistance to acids, and to alkalis to a remarkable degree, for a slightly acid state may mean serious loss of health, and similarly with slight increase of alkalinity. The give and take, or reversible condition is a marked feature of the body fluids.

In neutral solutions where calcium phosphates are present alteration in the state of precipitation may be effected by any one of several factors. We are not alone concerned with the calcium and phosphorus, as has been pointed out. A state of supersaturation may exist by virtue of the maintenance of neutrality and hence altered in the direction of precipitation by increase in alkalinity, or in the direction of decrease of calcium phosphate saturation by increase in acidity. In a phosphoric acid solution to which we have added lime water there appears a precipitation before neutrality has been reached, and the precipitate upon analysis will be found to vary as we approach the neutral condition. First of all an acid phosphate appears ($CaHPO_4$) which then redissolves and gives rise to more and more tricalcium phosphate ($Ca_3(PO_4)_2$). With the addition of more and more lime water the precipitate is increased. Not much change in acid reaction has been accomplished all the while the precipitate is being formed, in spite of the fact that really

large quantities of alkali have been added. We would find the hydrogen ions were about the same number or their concentration would be quite uniform from the time the precipitate first appeared until no further precipitate were formed. From the point where no further precipitate is formed profound changes occur. The addition of still more lime water at this point causes the acidity to lessen, and we pass rather rapidly through neutrality to an alkaline condition. The composition of the precipitate is changed in this process and we find upon analysis that not only is tricalcium phosphate present but the compound referred to above, oxyapatite, which is infinitely less soluble than other phosphates of calcium. In the neutral zone slight addition of acid or alkali prominently affects the reaction, but does not appreciably alter the amount of the precipitate. What occurs is the change in composition of the precipitate. Prompt reversibility occurs at certain points in this neutralization process, and very sluggish changes at other points. We are led thus to conclude from the studies of the formation of calcium phosphates that much depends upon the acid or alkaline region where the salt is formed. We do not know as much as we should like to about this. But we are sure of the reversible changes with respect to the formation and solution of calcium phosphate. From the moment when the first precipitate arises we are aware that it does not mean calcification is necessarily to follow. Many variable factors may enter into the picture to reduce the precipitate or change its character.

We might have pointed out earlier that the precipitation is also the result of the insolubility of the calcium phosphate. We have considered the formation of the calcium phosphate by virtue of the constant additions of calcium and phosphate to the intercellular fluid. The continued addition of these factors soon creates a condition whereby the fluids will not dissolve any more. Hence we are concerned with the solubility of the salts like calcium phosphate as much as we are with the reversible and balanced conditions which exist. For the initiation of calcification is dependent upon the state of insolubility being reached before we shall have any solid or crystal calcium phosphate formed. Solubility, however, may be determined in several ways. With relatively insoluble materials like the calcium salts we are most interested in the solubility with reference to calcium phosphates in fluids like the body or intercellular fluids and at body temperature. As we shall see below it makes a considerable difference whether we determine how much calcium phosphate can be added to a solution like serum or gelatin or water before a saturated condition has been reached.

We have usually considered solubility in water. Distilled water has as we have seen a neutral reaction, and equal concentrations of hydrogen and hydroxyl ions. With more and more hydrogen ions present more calcium phosphate will be dissolved, as is the case with carbon dioxide solutions. In the presence of neutral salts like magnesium sulphate and sodium chloride, and metal salts like lead chloride and zinc sulphate more calcium phosphate is held in solution than in water. Blood is a composite solution of salts, proteins, carbon dioxide, etc. Where water has a hydrogen-ion concentration of

0.000,000 1 N (i.e., 1.0 x 10^{-7} and a P_H* of 7.00), blood has 0.000,000,047 N hydrogen ions (i.e., 0.47 x 10^{-7}, $P_H = 7.43$.) Hence tricalcium phosphate in distilled water will be different than in serum, as shown by Table I.

It is to be noticed that the tricalcium phosphate is almost twice as soluble in serum as in water, whereas calcium carbonate is about six times as soluble. In a recent study of blood serum of infants actively suffering from rickets, in comparison with others in a condition of healing rickets and some with no rickets, Holt[3] found that although the concentrations of calcium phosphate were variable they were still above the amounts which can be kept in solution in blood serum at body temperature if shaken to equilibrium. This was found also true for experimental rats. The normal infants and experimental animals it must be pointed out had concentrations of tricalcium phosphate which were so much in excess of the equilibrium value and in comparison with those in active rickets as to suggest that the rate of calcification is to some extent at least dependent upon this excess. In other words there is a state of supersaturation and the larger this is the more rapid would be the formation of the precipitate of solid calcium phosphate. The saturation of the phosphates in these solutions has been compared when the hydrogen ions are similar in concentration to that existing in blood, i.e., $P_H = 7.4$.

TABLE I

SOLUBILITY OF CALCIUM SALTS (PAULI AND SAMAC)[5]

	PER CENT SOLUBLE IN		
	WATER	SERUM	1.5% GELATIN
$CaSO_4$	0.223	0.226	0.295
$Ca_3(PO_4)_2$	0.011	0.021	0.018
$CaCO_3$	0.004	0.023	0.015
SiO_2	0.023	0.030	0.027
Uric acid	0.040	0.057	-----

This brief consideration will have sufficed to make it apparent that calcification is not initiated under simple conditions. We have still to remember that the process requires a suitable association of calcium and phosphate. This association proceeds, however, under rather complex conditions. The very reaction which tends to produce tricalcium phosphate and even more basic phosphates is reversibly affected by several factors, such as the hydrogen ions, carbon dioxide in the form of bicarbonates, neutral salts, and the supply of the calcium and phosphate ions elsewhere in the living body. In this manner one may more readily understand certain changes which tend toward decalcification, yet with slight alteration proceed in the direction of calcification. The exceedingly slow formation and delayed precipitation of the finely divided particles of the insoluble salts of calcium are processes not to be forgotten in studies of this kind. There may be greater significance in these low rates of change than we now realize. Further than this we are made aware of the state of supersaturation and the apparent fact that calcification depends

*P_H is an index number now commonly used with hydrogen-ion concentrations calculated from the values determined in several ways.

$$P_H = \log 10\ 1/(H)^+$$

The number is thus the negative logarithm (base 10) of the hydrogen-ion concentration.

in some part upon the amount of this saturation, proceeding more rapidly the greater is the amount of the undissolved material held in solution. Finally it is important to remember that in faintly acid and neutral solutions we may have the tricalcium phosphate formed as well as in alkaline solutions, hence in the body fluids under conditions which are similar to the blood and saliva bathing living cells we may study the formation of the bone salts.

CRYSTALLINE CONDITION IN BONE

The conditions just referred to have anticipated a fuller statement concerning the formation of crystals of calcium phosphate in living tissues. From the general literature one is led to think of bone as containing amorphous inorganic materials rather than crystalline. Examination of fresh bone, shows the presence of crystal structures of some phosphates of calcium. Other calcified structures formed by living cells likewise indicate crystal formation. Recently Shaxby[6] has photographed with monochromatic x-rays the crystals of mother-of-pearl and found it to be comprised of a definite crystalline structure of calcium carbonate, aragonite. The method he used will augment study of thin sections by polarized light and permit one to distinguish the presence of crystal masses more clearly. So that you are not confused by the reference to the x-ray method it may be well to point out the crystals are identified by a diffraction pattern on photographic film and not by a shadow or density picture. A finely powdered mass of the substance to be examined is placed in a small capillary tube of glass or quartz close to a hole made in a lead sheet. About the capillary tube is placed hemispherically a strip of film. X-rays passing through the pin-hole are affected by the crystals of the mass only and the rays are scattered, or diffracted, affecting the film at certain points. The method of x-ray analysis is applicable to qualitative determination of the powdered masses, but may to a limited extent be used for quantitative study.

There has been no great application of polarized light to the study of developing bone, or formed bone. Skeletal developments in marine embryos have been followed with polarized light and indicate that crystal structures appear very early in the living tissues. We have observed amelification by this method in order to determine the earliest appearance of calcium crystals. Enamel of teeth which have been recently erupted exhibits considerable differences from enamel of old teeth, suggesting transformation from a phosphate of calcium to a carbonate.

It appears from preliminary studies that the precipitation of the calcium salts in the intercellular fluids is in the form of crystals. The matter requires further investigation for two reasons. First of all it has been presumed by some investigators that the appearance of crystals in bone and dentine indicates decay, much as the crystals appear in glass and metals under strain. Where crystals arise fractures are likely to result as is evidence in glass when strained and subjected to changes of temperature. But decay is not necessarily indicated by the appearance of the crystals. Embryonic bones and shells have crystals throughout their development and with apparently an important part to be played by them. Secondly there would appear to be some relation between the calcium crystals and the organic matrix. Whether or not the hardening

process depends upon the finely divided crystals as in cement is to be left for study. It would appear as though changes involving the crystal structure play an important rôle in functioning bone.

ALTERATIONS IN BONE

We have indicated above that to initiate calcification not only calcium and phosphorus must be present in dissolved and ionized forms but a state of supersaturation exists and this gives rise to precipitation of finely divided crystals of calcium phosphate. The origin of bone in cartilage and membrane depends upon the presence of the solid calcium salts. In the early stages of calcification reversible processes have been considered. After the solid has been invested in the organic matrix we are not certain how far reversibility can be considered. What applies to early calcification may not in the same degree apply to the processes during the hardening of bone, or to changes in fully hardened bone. There are other conditions to consider which are involved in any discussion of resorption and changes in bone once it is formed.

The fact that bone acts in a different manner to stresses and to metabolic changes as compared with cartilage suggests that the precipitated calcium salts affect the matrix. It is quite possible that the cartilage is altered and becomes a calcium compound. Both collagen and chondroitin are soluble in calcium salts to a certain extent. Rearrangements of the cartilage which has been formed before the osteoblasts appear seem to be indicated by the fact that the analyses of bone from which the lime salts have been removed are more like the analyses of connective tissue substance, collagen. Study of the alterations in formed bone will in the future take into consideration this aspect of chemical change, viz., interaction between the matrix and the calcium salts. We must know before we can explain resorptive processes what chemical changes occur in those masses which have the composition of normal bone.

It is also possible that a change is undergone by the calcium salts after deposition. We may assume the precipitation in the matrix of tricalcium phosphate, finely divided crystals of definite structure, $Ca_3(PO_4)_2$. Bassett has suggested that the stable state of the calcium salts of the bone approach a more basic condition, namely $(Ca_3(PO_4)_2)_3.Ca(OH)_2$. In a solution of phosphoric acid to which has been added excess of lime water until chemical neutrality is reached one will find this more basic compound, oxyapatite. This phosphate can exist in contact with faintly acid, neutral and alkaline solutions. If formed in bone as development proceeds dissolution is increasingly difficult as compared with the presence of carbonates and less basic phosphates. It is suggested that this alteration be considered.

These possibilities have been pointed out since changes in young bone have been found to be more rapid than in advanced skeletons. The formation of new bone has three possible conditions the first of which is the organic matrix to which is merely added the calcium salt. Second some change may be effected in the cartilage mass which takes the form of a chemical union with the calcium or calcium salt. Or thirdly, the deposited calcium salt undergoes changes one of which is toward the most basic phosphate of calcium and

providing a more durable inorganic material. The state of supersaturation of the calcium salts in the intercellular fluid and their slow precipitation may permit the more rapid chemical and physical changes of early formed bone. But as the hardening processes go on whether of a physical or chemical nature the course of changes will be different. The movement of teeth and their subsequent retention thus depend upon different phases of the calcification process. Movement requires resorption; retention requires the formation of hardened or stable bone. Considerations of the simpler conditions under which deposition of calcium salts occur in the organic matrix will need to be kept separate from those of the resorption of the hardened substance.

Alterations in formed bone apparently involve a rearrangement of the factors which have led to the formation of the calcium salts, and no foreign factor need be involved. Some of the solid mass may be dissolved and transferred to a near-by region with consequent reprecipitation and recrystallization. It has been customary to consider resorption of this order. Pressure atrophy seems not, however, to be so simply explained. Changes in the nutrient circulation are here involved, probably involving carbon dioxide. Cartilage under the same stress is not altered as is bone and seems to depend in this particular upon the lower metabolic reactions and diminished circulation. In other words the respiratory conditions of bone are involved in pressure atrophy. One may ask whether alterations in formed bone are best exemplified in the atrophic changes resulting from pressure and metabolic disturbances, or whether they are affected by a direct alteration in the inorganic calcium salts.

SUMMARY

In this paper we have pointed out that (1) ossification is a special case of calcification, dependent upon chemical and physical processes observed wherever radicals of calcium, carbonate, and phosphate exist in solution, both in the body and outside; (2) that bone comprises a solid phase in which a crystalline salt of calcium exists, in a finely divided state, chiefly of calcium phosphates, and upon which certain structural characteristics of bone depend; (3) that the chemical changes in the calcium salts may be brought about in the calcium phosphates through rearrangement of the elements both in solution and in the solid state, with shift of the hydrogen-ion concentration and the formation of the more soluble bicarbonates; and (4) that bone is finally effected through a hardening or setting process involving an interdependent relation of the calcium salts and the organic matrix.

The several factors fundamentally essential to calcification which have been discussed above are each approachable from the laboratory point of view for purposes of study and by methods which seem satisfactory. We have been most concerned for the present with certain physical aspects of the calcium salts, and of embryonic bone.

The means by which retention may be effected through the proper control of the fundamental factors is not to be lost sight of. The pressure changes in the movement of teeth will be studied as soon as underlying changes are better known.

Bone is a complex tissue and chemical analysis does not wholly provide us with information about the constituents, for we are more interested in functioning and developing bone than in composition of dead bone. Our progress along physiologic lines is, however, beset with difficulties as you may well recognize.

It is a pleasure to have the opportunity to address your society and although the material contributed is small I hope it provides a useful outlook. I am also grateful for the assistance in beginning our laboratory work to your associates Drs. Mershon and Johnson who have been of help this year in getting experimental work started. Their enthusiasm and interest in the subject has provided an added stimulus to attack the fundamental problems upon which a solution of some orthodontic puzzles appear to depend.

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THE GONIOMANDIBULAR ANGLE IN DENTOFACIAL ORTHOPEDIA*

(ABSTRACT)

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AMONG the anthropologic measurements indispensable in orthodontia, that of the gonion angle is one of the least studied.

The purpose of this paper is to show what we know of this question, to establish a simple and practical method of measuring this angle on the living, and finally to show the necessity of explaining the factors which intervene to determine its physiologic value and its pathologic variations.

I. ACTUAL STATE OF OUR KNOWLEDGE—THE GONION ANGLE IN ANTHROPOLOGY

The goniomandibular angle (mandibular angle), is the angle determined by the inclination of the posterior border of the ramus of the mandible on the inferior border of the horizontal body of the mandible.

A. *Its Measurement.*—It has no part in anthropology for measurement on the living.

B. *Results, Physiologic Variations.*—The results given by the anthropologists are so variable that they are without any accuracy. That appears due at first to the want of accurate methods of measurement. The majority of the measurements, however, have been taken without determining if the jaw examined was normal or not; without thinking of the factors which can produce variation in the angle. These reservations made, one is able to observe the following principal variations.

1. Variations Due to Age. These variations, very important to us, have been insufficiently studied, and the factors which determine them are little known. All that one can say is that the gonion angle is very obtuse in the infant, decreases in degree up to the time of adult life and enlarges anew with old age. And yet this last modification is contested by Kieffer. From the measurements established by Engel, Welcker, Ruge, Sappey, Renard, Topinard, Debierre, Herpin, Kieffer, and Martin, one is able to establish the following average of variability:

150° to 135°, at birth
140° to 130°, when the first dentition is finished
130° to 120°, up to the time of eruption of the twelve-year molars
120° to 150°, in old age

One sees from these figures that some new measurements are necessary and these must be taken at different periods of the dentition.

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2. Variations Due to Race. It is here that the writers give the greatest variations running from 110° to 130° in the adult. Here is the general average adopted: From 110° in the prehistoric man, the angle remains little raised in certain primitive races, as the Eskimo (115°). It will be from 115° to 120° in the Asiatic races and the American Indians, and attains 120° to 125° in the African Negro. In the Europeans it varies between 125° and 128°; the German type having a greater angle than the Celt and the Latin.

These sums constitute nothing but approximations without great accuracy.

3. Individual Variations. If in certain pure races, the angle seems to vary a little from one individual to another, it is not the same way in the majority of modern races, and some important individual variations have been established.

4. Variations of Sex. The angle is nearly always higher in the female than in the male, from 2° to 5° approximately. In the Eskimo it is some-

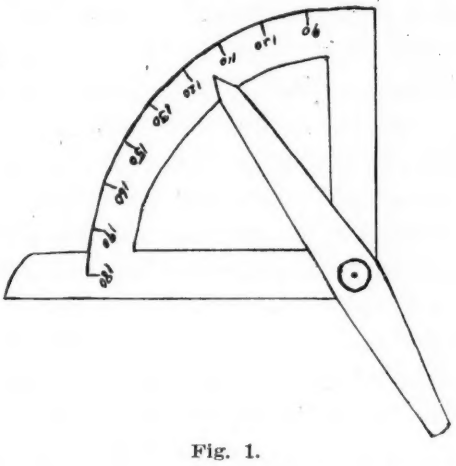

Fig. 1.

times the same; this is due to the development of the masticatory apparatus in the female.

5. Right and Left Side Variations. These variations, not noticed in general, are frequent and we have observed them in nearly all cases; they are in ratio with the normal facial asymmetry.

C. *What Do We Know of the Factors Determining the Value of the Gonion Angle?*—We know little in reality.

1. It is certain that the dentition plays an important rôle; it is this which determines the variations in the course of growth. Renard has included the size of the teeth; the angle being all the more reduced as the teeth are larger.

2. The form of the cranium seems to play a certain rôle; the dolichocephalic will have an angle smaller than the brachiocephalic. The form of the face also influences it; a long face has a more obtuse angle than a short face.

3. The functional factors play the predominating rôle, and in particular that of mastication. The more powerful the masticatory muscles are, the less obtuse is the angle.

It will be important to repeat this study on a new basis. Measurement on the living permits the gathering of more accurate ideas than observation on the skull, thanks to the clinical information which accompanies it.

II. THE MANDIBULAR ANGLE IN DENTOFACIAL ORTHOPEDIA

Anthropologic methods do not provide for measurement on the living. This is, however, indispensable, for this alone permits us to elucidate the problem of the factors which determine it. Knowledge of the mandibular angle in orthodontia will complete our diagnosis, will aid us in establishing our prognosis and our treatment.

1. *Measurements of the Mandibular Angle on the Living.*—Diverse methods have been proposed. Rubiston and Simon determine on photographs the approximate degree of the angle, but without sufficient accuracy. Marouze has constructed a small device which indicates the complementary angle, but with which the measurement is rather delicate. Ruppe has added to his gnathometer a device permitting the measurement of the angle.

Personal Method.—These methods have indicated to us a want of accuracy or of simplicity. Therefore, we have established a model of a mandibular goniometer (constructed by Collin) in which the manipulation is easy and the reaction direct. It consists essentially of a fixed part representing a sector of 90° graduated from 90° to 180° on which is placed a movable index.

To take the measurement, one moves forcibly forward the mandible of the subject to be examined and then applies as accurately as possible the two branches of the apparatus against the horizontal border of the mandible and the ramus of the mandible. A simple reading on the graduated disc gives the degree of the angle. The measurement should be taken on the right and left.

2. *What Aid Does Measurement of the Mandibular Angle Bring to Diagnosis?*—We note first that the measurement of the mandibular angle completes an ensemble of cephalic and facial measurements (cephalic index). These last comprise the transverse measurements (bizygomatic and bigonial distances), sagittal (auriculofacial radius) and vertical (height of face and its two sections—upper and lower).

A. Certain facial deformities always accompany anomalous value (i.e., the degree) of the mandibular angle. If the transverse deformities do not appear to play any rôle, the sagittal deformities often accompany the variations in the same way that certain vertical deformities may, through diminution or enlargement of the lower section of the face. The most accentuated variations of the angle are brought about through the troubles of development of the mandible.

B. Clinical Observations. The summing up of our observations permits us to establish the following conclusions:

(1) We consider as *normal angle,* in the infants and in adolescents, which we have examined, an angle which varies between 120° and 130°.

(2) The diminution of the angle under 120° is not very frequent; its method of formation is difficult to establish. It seems to exist always in certain

cases of mandibular retrusion, with pronounced diminution of the height of the lower section of the face. This diminution occurred in one case to 106°.

(3) The augmentation of the angle is more frequent and easier to explain. Here is the result of our observations:

(a) Lack of mandibular development is a frequent cause, which might operate on it from true atrophy through conservation of the infantile nature (temperomaxillary ankylosis) or from simple arrest of development. The angle can attain and go beyond 140°; the profile is deformed by a pronounced labiochin retrusion.

(b) Mandibular hypertrophy: this may exist in the true acromegalic, with or without giantism, it may be certain dystrophic troubles of the adolescent. The prognathism of the Hapsburgs comes in this category. The obtuseness of the angle may be considerable and is accompanied here by labiochin protrusion.

(c) The sagittal deformities through increase of the nasochin distance with or without open bite often accompanies a greatly obtuse mandibular angle, as was demonstrated by Frey and de Nevreze in 1909. We have observed many interesting cases.

(d) The open bite alone is not sufficient to produce an obtuse mandibular angle notwithstanding the affirmations of Lind.

3. *The Mandibular Angle Considered from the Point of View of Treatment.*

A. The existence of angular deformities can obscure the prognosis and complicate the treatment. In particular we call to the attention of the Congress the cases where there exists a continuous and progressive increase of the mandibular angle. We have observed many cases; in one or two the angle had passed from 130° to 145° in two years. This tendency of adolescence should make us careful in our treatment. It is necessary above all to have general medical treatment (endocrine); sometimes it is necessary to have recourse to surgical treatment (resection of the condyles).

B. Can We Modify the Degree of the Mandibular Angle by Our Treatment? This question has not yet been determined for want of measurements. In the treatment of certain sagittal deformities, we can, a priori, produce possibly a condyle displacement, possibly an angular modification, possibly a general osseous transformation. Successive measurements in the course of treatment will permit us to determine if the mandibular angle is modified and in what proportions.

NEW METHOD FOR THE DETERMINATION OF THE NORMAL ARCH BY THE FUNCTION OF THE FACE*

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ANTHROPOLOGY, by the precision of its methods, is called to play an important rôle in orthodontia. The present work has for an object the showing of the importance of anthropology in the rational determination of the normal arch, although a priori, anthropology seems useless for such a subject. This study is divided into two parts: The first, to show the insufficiency of actual (existing) methods; the second, to show the basis and the practical exposition of a new method for the determination of the normal arch.

PART I. ACTUAL METHODS

In this part, I wish to demonstrate that none of the existing (actuelle) methods for determination of the normal arch can be considered general and universal. The one group has as a basis of calculation the dimensions of the dentures or dimensions within the dentures and consists of metric methods (ratios) and of graphic methods with various (sundry) curves; the others are based on the occlusion itself.

I. *Methods for Determining the Dimensions of the Normal Arch by Ratios or Indices of the Dentures.*—These methods have been presented by de Croes (1903), Campion (1906), Pont (1907), Williams (1917), Carrea (1922). We have studied them closely, by utilizing clinical observation and especially by the examination of numerous skulls of all races that we have been able to observe in the Museum of Natural History of Paris. The measurements taken, which cannot find a place in this résumé, permit the establishment of certain important principles.

A. None of the ratios established by the authors named can serve to establish in certain manner the dimensions of a normal arch.

(1) A constant ratio does not exist between the incisor breadth and the breadth of an arch. The incisor-premolar ratio of Campion is a relation eminently variable, which Campion had, incidentally, well established himself.

(2) A constant ratio does not exist between the molar-perimeter and the breadth of an arch. A relation, established by Carrea, for the deciduous denture and the permanent denture is, too subject to variations to be adopted.

(3) A constant ratio does not exist between the sum of the diameters of the superior incisors and the breadth of the arch.

Basing it on the well-known curve of Hawley, Pont established in 1907 a premolar index, fixed at 80 in a normal arch, and a molar index fixed by

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him at 60. The researches of Comte, in 1924, as well as my personal observations, show that these indexes are themselves very variable. Indeed, one observes frequently the same sum of incisor diameters in arches altogether different, some wide, the others narrow. Often a wide arch has incisors which are narrower than a narrow arch. The index of Pont, however, is not always inexact; it seems to correspond with the reality in those individuals whose cephalic index varies between 74 and 78.

(4) A constant ratio does not exist between certain intradenture diameters, be it between two transverse diameters, or between a transverse diameter and an oblique diameter. It seems, á priori, that one might be able to establish a fixed ratio between two transverse diameters, as between the lines "a" and "c" of the ratio of Williams. But it is necessary to note that Williams, himself, does not assure any accuracy except for a given ethnologic type, that which he describes as the American type. The observations of Comte and myself also show that this ratio itself is not fixed.

For a still better reason, it is impossible for a constant ratio to exist between a transverse dimension and an oblique dimension.

Besides the measurements we have taken, the study of the arch index shows it in absolute manner.

B. The study of the denture dimensions shows only a certain correlation between the diameters of the different teeth.

Observation shows, in fact, that of one arch in relation to another, the diameters of the different teeth—incisors, canines, premolars and molars—vary the more often, following a similar rhythm. (See on this subject the figures of Black, de Terra, Choquet.) But here still this rhythm is not invariable, particularly in that which concerns the superior lateral incisors, the canines and the wisdom teeth.

These ratios, like the rest, cannot serve us in determining the normal arch.

C. The study of the intradenture dimensions demonstrates only the great variability of the dimensions of the permanent arch.

Among the dimensions, two particularly are important, those which serve to determine the arch index:

$$\frac{\text{Maximum breadth of arch} \times 100}{\text{Maximum length of arch}} = \text{Arch index}$$

This index varies following several factors.

(1) Following age: At birth, the arch index calculated on the dimensions of the alveolar arch fluctuates around 140. It increases afterwards to vary between 170 and 190 up to the eruption of the six-year molars. It seems to work out at this time the differentiation of the arches; from this stage the variations approach nearer to those of the adult.

(2) Following the ethnologic type: With the adult, the arch index varies between 97 and 158, the extreme variations that we have observed. These figures concern only the superior arches with all their teeth and include the wisdom teeth. The variations of the arch index show that, in some distinct pure ethnologic groups, types of arches characterizing a given group

do not exist. In all countries there exist arches wide and short and arches long and narrow. It is, therefore, necessary to make provision for the great variations when one wishes to determine a normal arch.

(3) Following the individuals: In actual races so mixed, we must, therefore, above all, consider the character of the individual arches, for variations sufficiently great can exist in the same family.

II. *Methods of Determining the Form of the Normal Arch With the Function of Certain Denture Dimensions.*—These methods are numerous; Table I is a résumé of the principal ones:

TABLE I

PART OF THE ARCH		NATURE OF THE CURVE	POINT DE DEPART (BASIS OF CALCULATION)	ARCH	AUTHOR	DATE
Anterior part, only		3 segments of the circum.	Diameter of 2 incisors.	Mandibular	Korbitz	1911
		Half circum.	Diam. 1+2+3½	Maxillary	Sved	1917
Complete arch	1	Anterior arc of the circle. 2 lines diverging from the laterals.	Diam. 1+2+3	Maxillary	Bonwill Hawley	1889 1904
	2	Anterior arc of the circle and 2 posterior segments of the circum.	Diam. 1+2+3	Maxillary	Gysi	1895
					Herbst	1907
				Mandibular	Rickter	1909
				Maxillary Mandibular	Carrea	1919
				Maxillary	Gaillard	1921
	3	True ellipse.	Sum of the diameter of all the teeth and a half-arch.	Maxillary	Herber	1907

Their study allows us to apply to them the following criticisms:

A. Individual Criticisms of Each Method:

(1) The curve of Korbitz, constructed empirically, does not correspond to the reality in its anterior part; the posterior part of the curve is not indicated.

(2) The curve of Sved, graphic application of the method of Williams, is liable to the same objections. Moreover, Sved does not tell us how to construct the posterior part of his curve.

(3) The curves derived from that of Bonwill are more interesting. They are divided into two groups of two different types of curves, which, identical in their anterior part, differ in their posterior part. In the first type, in which the better construction is that of Hawley, the lateral lines are straight and strongly diverging; the curve in its entirety approaches a parabola or better a hyperbole. In the second type, in which the simpler construction is that of Herbst, the lateral parts are curvilinear; this curve represents approximately an ellipse. These two curves of Hawley and of Herbst have rendered, and render yet, great service to orthodontia, by their simplicity of construction.

All the curves give rise to the following considerations:

(a) We have established that a constant ratio does not exist, in an arch, between the sum of certain denture diameters and the dimensions of that arch. One cannot, being aware of the variable form of the arch, employ these same diameters as a basic point for the graphic construction of an arch, for the reasons already given.

(b) One must take exception to the claim for these constructions to always give, for the same breadth of incisors and canines, an identical arch. Clinical observation and anthropologic statements, show that, for the same incisor-canine breadth, one can find many different arch forms.

(c) It is not necessary to conclude from these remarks that these curves are always inaccurate; as we have said of them apropos of the Pont index, they are sufficiently accurate with subjects in whom the cephalic index varies between 74 and 78.

(d) Between the two types, parabolic and elliptic, we prefer the elliptic as more exact and more harmonious.

(4) The curve of Herber is a true ellipse, easy to construct. It is possible, for its construction, to except the necessity for the presence of all the permanent teeth, something which the orthodontist has never encountered. Morover, the ellipse of Herber is of unvarying form, being given the fixed ratio of dimensions between the large axis and the small axis.

B. General Critique:

All of the preceding graphic methods raise the two following serious objections:

(1) All suppose that the form of the arch is invariable, when in fact the variations of form of the normal arch are very numerous.

(2) All these methods consider only the permanent arch, and do not think in any way of the deciduous arch, of the arch at the period of transition. A single effort has been attempted by Bogue to determine, in the deciduous denture of a child, the dimensions of his permanent arch. But no author has been found to establish with an infant of a given age the form and the dimensions which should present themselves in his arch at this epoch of his dentition.

III. *Methods of Determining the Curve of the Two Arches by the Function of Articulation.*—By reason of the capital importance that the majority of orthodontists accord to occlusion, certain writers have thought that the only rational method was to determine the form of the arch by function of the occlusion itself.

(a) The better known methods are those of Stanton (1916), Gilpatric (1917), Hoggan (1920), Johnson (1923). They are all derived from the same principle, established by Stanton, that, the occlusion being the capital point, the only rational form of the two arches would be that which permitted the best articulation.

For analysis, these methods can be divided into two groups. Stanton measures carefully the width of the maxillary and mandibular teeth, traces them very much enlarged on two charts articulated in an occlusograph. The

maxillary and mandibular teeth are placed on the charts in a manner to assure the best occlusion. This obtained, the form of the arches so established is the ideal form for the case studied.

The other methods proceed in the same manner, but make use of an anatomic articulator, on which are placed, in the one case, anatomically formed teeth, in the other, mouldings in amalgam of the tooth crowns of the subject himself.

(b) There has not been sufficient time for us to verify clinically and experimentally these methods, but the work of their authors suggests the following observations:

(1) These methods realize practically the laws of occlusion, many of which have been established by the prosthesists. They evidently ought to give an interesting functional result, since the teeth so disposed, are placed following the rules adopted for the construction of the complete dentures.

(2) But can one say that the arches so determined really have the best form for the subject considered? The experiments undertaken have shown that one can obtain for a single denture several different forms of arches which often are not very harmonious. In general these arches appear to be too wide in their anterior part.

(3) Our observations permit us to affirm that contrary to the affirmations of Stanton, the form of the dental curve is not dependent on the individual dimensions of the teeth. Some serious modification of the dimension, it may be by abrasion of a large portion of the crowns, it may be the absence of a tooth itself, can modify the form of the arch.

(4) Some workers have shown that the ideal occlusion was not alone the normal occlusion (Choquet, Schroder), and that articulation "one on another" ought to be considered as normal. Evidently we should always seek for the ideal occlusion, but this does not constitute an absolute rule as far as anthropology is concerned.

(5) The work of Stanton forms none the less a very interesting effort and we think that it will be necessary to give it some consideration in the future in order to assure the best possible articulation. It is to be hoped that these methods may be studied experimentally.

(6) These methods have only been applied, like the preceding ones, to the permanent dentures. Anatomic articulators for the deciduous dentures have not been established.

(7) The occlusion ought to be taken into consideration, not so much to decide the form of an arch, but simply to adapt the form of the arch to the best functional utilization.

PART II. METHOD OF THE WRITER

In the preceding discussion it was seen that all the existing methods, all giving practically some interesting results, failed to meet the requirements of a general method. We must, therefore, take account of the denture or "peridenture" dimensions in order to establish the dimensions or the form of an arch. The occlusion must be taken into consideration solely in order to adapt the arch to its best functional utilization. We must then look elsewhere, and

determine a method which permits the individual determination of the arch, not only for the adult, whatever may be his ethnologic type, but also for the infant and the adolescent in the course of their growth. I think I have met these conditions.

We will consider successively, the basis of my method, then its practical utilization.

I. *Basis of the Method.*—Our method rests on several points which we are about to examine in succession.

A. The determination ought to be carried on a maxillary arch in preference to a mandibular arch.

(1) The superior maxilla being fixed at the base of the cranium, the factors of development of the arches operate well and even better on the superior arch than on the lower; we have here in life moreover the respiratory and masticatory factors and the force of the development of the base of the skull.

(2) In the normal arches, according to our anthropologic observations, the maxillary arch is often more regular than the mandibular.

B. The dimensions of the normal arch are governed particularly by the corresponding dimensions of the face.

The factors which determine the form of the arches are numerous; the hereditary influences appear to operate more than the acquired influences, but these are not negligible. Among the hypotheses already enumerated, it is necessary to reject completely the influence of temperaments, and to accord great importance to the functional influences, especially respiration and mastication.

A factor which has been particularly valued is the form of the skull (Osborne, Angle, Osburn, Ranke, Hrdlicka, Sullivan, Gregory, Pont, etc.). It is necessary to take account in a certain measure, of the fact that the base of the skull plays a more important rôle than the form of the vault.

But the predominating factor is the influence of the face and this influence can be differentiated from that of the skull. L. Williams and Hecht have been impressed by the influence of the zygomatic apophyses, but without seeing the prominent rôle of the face in the development of the dental arch. My personal researches in anthropology have shown me that the dimensions of the dental arch are governed by the corresponding dimensions of the face.

Rule 1.—A constant ratio exists between the width of the arch and the width of the face.

The width of the arch considered is its greatest width taken between the vestibular aspects of the teeth; the width of the face is indicated by the greatest bizygomatic distance (interzygomatic breadth). After having measured, in the Museum of Natural History of Paris, all the skulls possessing normal arches, we have proved that, in almost all the cases the breadth of the arch, though very variable, was one-half of the bony bizygomatic diameter. Some secondary factors, difficult to determine, interfere sometimes to slightly modify this rule, which remains accurate, more in the course of growth than

with the adult. We have established in order to determine a transverse arch-face index:

$$\frac{\text{Maximum breadth of arch} \times 100}{\text{Maximum interzygomatic arch}} = \text{transverse arch-face index.}$$

(a) During growth, this index varies slightly and oscillates around 50. We have verified it at different ages and with subjects belonging to very different races. The cranial series observed are not very numerous, as one has studied man a little, in anthropology, during his growth. But the results are all in agreement.

On the skulls examined, we have observed that it is necessary to measure the greatest width, not to the level of the teeth present in the arch, but between the external alveolar borders of the first teeth to come out, that is, the alveoli of the second deciduous molars up to the completion of the deciduous denture, the alveoli of the first permanent molars from three to six years, etc.

The extreme variations of the transverse arch-face index are between 48.5 and 52; that is remarkable, especially as the width of the section of the arch varies from 33 (minimum at birth) to 60.

(b) With the adult the variations are a little greater; that should not surprise us, for we know the great variations in the face and arches following the ethnologic type and the individuals observed. The extreme values established are seen in Table II.

TABLE II

	NO. OF SKULLS	ETHNOLOGIC TYPE	MAX. WIDTH OF ARCH	BIZYGOMATIC DIST.	INDEX
Minimum	4769	Alfurn	53.	106	50.
Maximum	12207	Patagon	73.5	151	48.60

The index oscillates between 47 and 54, extreme values. In 75 per cent of the cases it varies only between 48.5 and 51.5, which constitutes an insignificant variation.

Rule 2.—A constant ratio exists between the length of the arch and the depth of the face.

When one examines the skulls on their inferior surface (norma Basalis) one is struck by the correlation which exists between the length or depth of the face and the length of the arch. Wishing to be more precise, we have taken a series of measurements and we have established that, in a general way the arch represents one-half of the auriculoincisal radius, measured with a radiometer or with a prosopometer. For greater accuracy, it is better to measure this radius in the plane of mastication, that is to say, in projection. The existence of a prognathism, more or less indicated, does not modify this rule. The measurement of the length of the arch is made between the incisal point and the maximum transverse diameter.

(1) During growth, the accuracy of this rule is remarkable, and this is a valuable idea for the orthodontist. The greatest transverse diameter being situated in the level of the first teeth to come out, the length of the arch is taken here between the incisal point, and the line passing the posterior

alveolar borders of the first teeth to erupt, the alveoli of the first permanent molars at six years, the alveoli of the second permanent molars at twelve years. Then the length of the arch is established as for an adult.

During the entire growth, the longitudinal arch-face index oscillates around 50.

(2) With the adult, the rule remains the same, taking account of some variations, owing to the difficulty of determining sometimes the widest point of the arch. This is found, according to the cases, at the posterior part of the second molars, at the anterior part or the posterior part of the wisdom teeth.

These statements will aid us greatly in constructing the curve of the arch.

(c) Third point. The forms of the normal arch are numerous, but they can be reduced practically to the variations of a single form—the ellipse (Comte).

(1) The forms of arches. Writers have concerned themselves but little with the form of the deciduous arch. Contrary to that of the adult, the deciduous arch varies slightly; it has nearly always been considered as a half circumference or an arc of a circle.

With the adult, one has described diverse forms—arches with the anterior part curved and lateral parts diverging curves (ellipse, ovoid); arches with curved anterior part and lateral parts diverging more or less rectilinear (parabole, hyperbole); arches with parallel lateral parts and with anterior part curved (arch U).

(2) Among these forms it is necessary to distinguish the frequent forms (ellipse, 75 per cent); less frequently (parabole 20 per cent); and more rarely (the others 5 per cent in all). Among the last the arches shaped as U and square are very rare and constitute more of a return to the forms of the ancestral anthropoid and they cannot be taken into consideration by the orthodontist.

The other arch forms can, as shown by Comte in 1924, all be brought back again to the ellipse. The ellipse is not an immovable figure and presents an infinite aspect; curved and wide it approaches a circle; long and relatively narrow, it takes a hyperbole figure or a parabola.

With regard to the deciduous arch; this should be considered not as an arc of a circle, but as a part of an ellipse having its large axis short.

(3) The orthodontist must always, in rebuilding the normal, establish an arch as harmonious as possible. The ellipse, so variable in its dimensions and so perfect in form meets all the requirements.

(d) Fourth point. The accuracy of the preceding conception can be verified experimentally.

(1) Principle.—To do all this we take each of the skulls studied, and construct for each an ellipse in which the small axis will be equal to one-half the bizygomatic distance and in which the large axis will be equal to the auriculoincisal radius. The ellipse so constructed should be superimposed on the curve of the arch of the skull examined.

(2) Construction of the ellipse.—The most practical methods are those of the "jardima" and the construction by means of an ellipsograph. We have used them all; in particular we have made an ellipsograph especially meeting the condition existing for the different types of dentures.

(3) Verification.—The curves constructed have then been compared to the curves of the normal arches we have noticed at the time of our examination. The result is most interesting, in many of the cases the curves are identical, in the others they are sufficiently alike to justify the value of the method we present.

II. *Clinical Application of the Method.*—It still remains for us to consider how to apply clinically the foregoing method studied on the cranium divested of its soft parts. From the foregoing it has developed that for each individual we can establish an ideal form of arch; by means of an ellipse whose dimensions correspond to the dimensions of the face.

This method is applicable to all ages.

The operation will consist of the following: First establish the length of the small axis of the ellipse.

1. Measure on the subject the bizygomatic distance by means of a large compass (see the works of Topinard, Martin, Hrdlicka).

2. Diminish the length found by the thickness of the soft parts. To do this fold the soft parts in the immediate vicinity of the zygomatic arch and measure the thickness of this fold with a foot slide (pied a couliss). The figure obtained represents exactly what must be taken off the cutaneous bizygomatic distance to have the bony bizygomatic distance.

Observations: The bizygomatic distance on the subject may not be normal. It is often diminished in our patients, especially the mouth (buccaux) breathers. But we can modify this facial dimension slightly; we must then consequently take it as a basis and not create an arch which will be too large for the face of our patient. In cases where this distance should be modified, either spontaneously, or after surgical intervention—adenoid vegetations for example—or after a maxillary displacement, it should be easy to modify accordingly the width of the arch.

But an arch must never be given a breadth larger than one-half the bizygomatic distance. This consideration permits us, if the subject has very large teeth, to practice extraction *rarely*. If the laws of occlusion forbid any extraction, the ratios between the arch and the face can render it necessary.

Second. Establish the length of the large axis of the ellipse.

In view of the deformities frequently observed, we must first determine if the auriculoincisal radius is normal or abnormal, in what way and in what proportions it is modified. To establish this diagnostic point, the best method is that of Simon, which we have used for many years, joining to a posterior frontal plane (plane of Simon) an anterior frontal plane passing through the glabella.

Three cases can be presented.

First case.—The superior incisal point is at its normal place on the sagittal plane.

We determine the normal position of the upper lip between the two frontal planes, the maxillary incisors touching the posterior surface of the upper lip. The measurement of the auriculoincisal radius gives at once the value of the large axis of the ellipse.

Second case.—The maxillary incisal point is back of its normal position.

In this case the upper lip is often retruded. A thickness of wax should be placed on the incisors (technic of Lischer) in a manner to reconstruct the normal upper labioincisal profile. The distance measured with a radiometer between the auricular line and the anterior part of the cushion of wax will give the normal auriculoincisal radius.

Third case.—The maxillary incisal point is displaced forward. The study of the profile by means of a metric photograph permits the determination of the degree of incisal malposition. The auriculoincisal radius should be diminished by a sum equal to the value of the incisal displacement.

3. To construct the ellipse.

The ellipse should be constructed as before. One should indicate on the circumference of the ellipse the area occupied by the different teeth, remembering that the ellipse corresponds to the *external contour* of the arch.

4. Put the teeth in place on the curve. Here we return to the general conditions of treatment. If one makes use of a vestibular arch, he should have, at the end of treatment, the form of the ellipse constructed. The measurements, taken in the course of treatment permit us to verify whether we have attained or gone beyond the area provided for each tooth.

As we have said before, it is good to take account of the occlusion which can be modified slightly and certain local details of the curve. But in its entirety it must remain a section of an ellipse in which the dimensions have been determined by the facial diameters.

Important note. This method is applicable to all ages and permits the treatment to follow the normal development of the individual.

DISCUSSION

C. A. Hawley.—The first part of this paper by Dr. Izard contains a comprehensive review of all methods of predetermining the correct dental arch in cases of malocclusion and a criticism of these methods, mainly on the grounds of inaccuracy. The basis of his claims of inaccuracy is that when these methods were applied to skulls having good occlusion, that were found in the Museum of Natural History of Paris, that they did not represent the arches existing there. This might be expected. The form of arch found in any individual represents the result of many factors, among which are inheritance, food and function. As these skulls were of all races and unknown individuals, it could not be expected that any formula or method would work out uniformally in these cases. All the methods he reviews were put forward as approximations and cannot be expected to work out accurately in individual cases.

As we cannot know the individual and cannot predetermine the normal for him, the problem of the orthodontist is to establish an arch in size and form most nearly the probable form which would be developed under the particular conditions of inheritance, food and function in which he exists. After doing this and retaining it for a reasonable length of time, these factors will inevitably force modification in the end in accordance with the force with which each of these factors act. The result cannot be positively known.

The most reliable guide must be an observation of the forms of arches reached by people who have lived under similar conditions and who have attained the nearest to normal—

who have attained what we can call a normal occlusion. Such an examination was carried on extensively by Dr. Bonwill on living people, as well as on skulls, and he constructed a certain form of arch which, with some modifications, seems to represent what is actually attained in most perfect specimens living under present conditions. In 1904-1906 I worked out a geometric formula by which an arch could be constructed for a particular set of teeth based on his findings, which have been in use ever since. They were also embodied in a set of charts to simplify their use. After more than twenty years observation and use, I am still convinced that they represent approximately, the form and sizes of arches that are being developed in normal cases under the conditions of living existing today in America. This arch form is not an ellipse. The line from the canine to the first molar is straight. The elliptic arch is not being developed in our present civilization and is not as artistic in the eyes of modern people as the Bonwill arch. These charts were never offered as anything but an approximation, but as an approximation, experience has shown they are reliable and sufficiently accurate.

The second part of the paper deals with a new method for determining the width of arches from measurement of the zygomatic width of the skull. As to this method, its value can only be estimated by others after practical experience in application of the method and there has been no opportunity for this. We might say, however, that the application of the method presents the same liability for inaccuracy that the author complains of in reviewing other methods of predetermining arches. It is unfortunate that Dr. Izard could not have

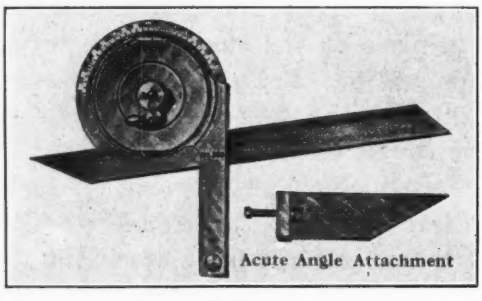

Fig. 1.

been present to present these papers personally and explain his methods. We must compliment him very highly for the studious research he has given these themes and assure him of our appreciation of his efforts.

Dr. R. Waldron, Newark, N. J.—I believe Dr. Izard is correct when he states, "Among the anthropologic measurements indispensable in orthodontics, that of the gonial angle is one of the least studied."

This statement needs no further comment, for it seems to be a self evident truth, and stimulates our interest sufficiently to force us to examine into this important and much neglected subject, which I believe contains great diagnostic possibilities.

Since the introduction of gnathostatics into this country, by Simon, in the spring of 1924, I have been measuring goniomandibular angles, and find it most interesting and of great value as a diagnostic aid.

The goniomandibular angle is formed by the posterior border of the ascending ramus, and the inferior border of the body of the mandible, and can be measured by three different methods.

First with an instrument such as the author has described or better with a universal bevel protractor, Fig. 1, which I think is superior to that shown by the author because the blade of the protractor which lies on the posterior border of the ascending ramus is adjustable for a long or short ramus ascendens and can be used as long as the ear will permit the blade of the protractor to go up the posterior border of the ascending ramus as is illustrated in Fig. 2.

Fig. 2.

Fig. 3.

A second way of measuring the goniomandibular angle is by the use of the x-ray. The operator can secure an extraoral picture taken at 90° from the facial profile. This gives an accurate picture or shadow graph from which measurements can be taken as shown in Fig. 3.

A third method is the one used by Simon which is done by marking with a skin pencil a point on each of the following places: the orbitalia, the tragus, the gonion and the gnatheon, and upon each of these marks a small piece of black court plaster is placed and then a photograph either one-fourth or one-half life size of the profile is taken, and upon the photograph these points are connected with lines showing the goniomandibular angle. This can easily be measured with a simple protractor and the angle recorded as shown in Fig. 4.

I have tried all three methods on a series of sixteen patients whose goniomandibular angles could not be considered very abnormal and I cannot find that any one method is more

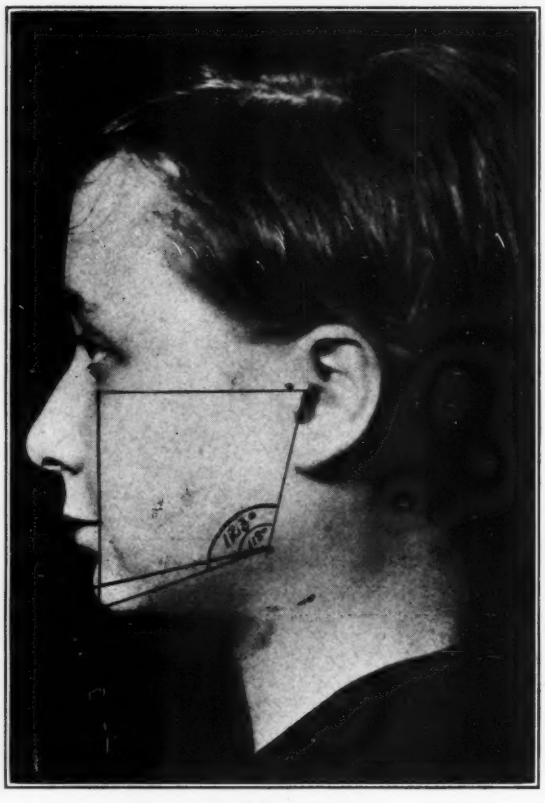

Fig. 4.

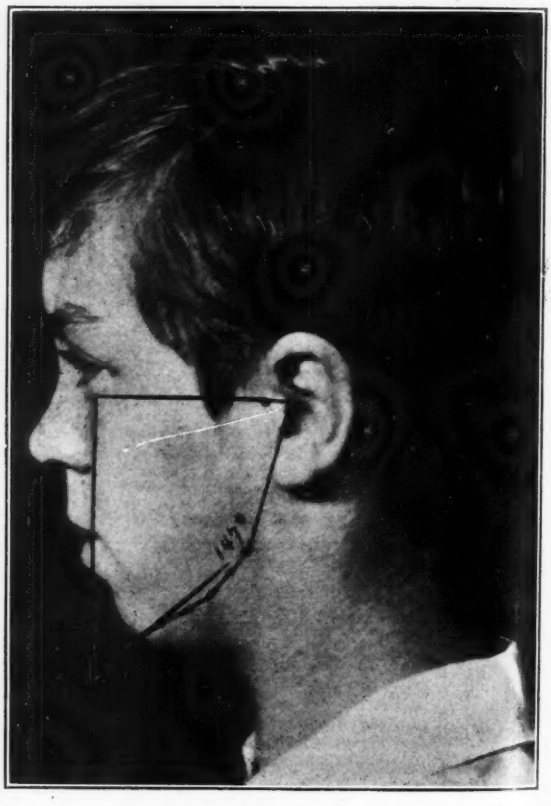

Fig. 5.

accurate than another, for upon repetition I have not been able to find a greater variation than 2°, and in the vast majority of attempts to remeasure this angle the results are identical.

It is, however, difficult to measure this angle with a protractor when the body of the mandible has an inferior border, which is markedly convexed.

For such a case I would prefer to mark off the position of the inferior border of the mandible with small pieces of black court plaster and photograph the patient, and upon the photo connect these points with lines.

By this method you cannot only have a record of the goniomandibular angle, but also a record of the mandibular curvature as shown in Fig. 5.

My observations have led me to believe that most cases presenting good occlusions plus well balanced faces come into that class where the orbital plane of Simon is in the canine region, but does not necessarily equally bisect the canine, and I find that the gonial angle in such cases range from 120° to 134°.

Cases where the mandibular dental arch is forward in its relation to the orbital plane or cases where the body of the mandible is short and its inferior border is convexed, usually have large goniomandibular angles. Fig. 5 shows such a case with an angle of 147°.

So called true distoclusion (not cases where we have the orbital plane passing between the mandibular canine and the first mandibular premolar with a protracted maxillary dental arch) usually have goniomandibular angles of less than 120° and is usually accompanied by a lack of vertical development of the osseous tissue in the premolar and molar area.

Whether we can increase or reduce this gonial angle by orthodontic treatment is a question which I will at this time neither affirm nor deny, for I have no cases finished which I have measured before treatment and I have only been measuring these angles for about two years.

Jackson, however, has contended for several years that he has caused changes in the goniomandibular angle by orthodontic treatment, but I do not recall where he has shown any definite measurements before and after treatment and while appearances would indicate great changes, appearances are deceiving, for which reason I have never been convinced.

We now have definite means of measuring if any change has taken place in the goniomandibular angle during orthodontic treatment, and I am looking forward in the not distant future for further enlightenment upon this subject.

I wish to compliment Professor Izard and to thank him for his valuable contribution which should stimulate us and our friends in the collateral sciences to further research upon this subject which, I believe is of such importance to orthodontia.

SOME NOTES ON INFECTIONS OF THE GINGIVAE ASSOCIATED WITH MALOCCLUSION*

By G. B. Pritchard, L.D.S., London, England

THERE is always the possibility of gingival infection arising as a result of malocclusion, and in many cases the possibility becomes a certainty. Malocclusion is one of the most important of the predisposing causes of gingivitis, and operates in three ways.

The first, and probably the most common, is that any abnormal arrangement of the teeth with each other or the associated soft parts, promotes stagnation of oral and food débris around their necks, and consequently renders normal cleansing by efficient mastication very difficult, and thorough artificial cleansing almost impossible. This makes the probability of the infection of even a normal gingival margin greater.

The second is that malocclusion in many cases causes traumatic occlusion. This results in a chronic congestion of the periodontal membrane which always spreads to the gingival margin, and so lessens the resistance of the tissues to the average amount of potential infection present in every mouth.

The third is like the second, with the exception that traumatic occlusion plays but a minor part, if any, in the causation. That is when there is slight general crowding of the teeth. There may be no great abnormality in the position of any tooth or group of teeth, no great variation from the normal in the shape or size of the arches, nor any abnormal relationship, either vertically or anteroposteriorly, between the arches themselves, yet the teeth are either permanently or intermittently packed too tightly together. This results in a mechanical congestion of the periodontal membranes and gingivae with results identical with those mentioned under my second heading.

In considering cases under my first heading, it is obvious that where the teeth are grossly out of their proper position—for instance a premolar erupted completely internal to the arch, or a canine completely external—the opportunities for retention of débris are ideal. The contact point is absent, or in the wrong place, the interdental papilla is abnormally formed, and in many cases the effort of mastication packs food directly into the gingival trough. These cases must in a very short time get a marginal infection.

The present day shortening of the alveolar length very frequently results in malocclusion of the maxillary and mandibular third molars. The mandibular molar under these conditions may be in any position between a horizontal impaction against the posterior surface of the second molar, and a partial or complete vertical impaction in the base of the ascending ramus, or it may not be impacted at all, but have its posterior cusps covered by the loose tissue anterior to the base of the ascending ramus.

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In many cases it lies external to the arch, erupting into the cheek. The variations in position of this tooth all tend to promote the stagnation and infection which is always so closely followed by a spreading gingivitis. It may be in normal position when its relationship to the rest of the denture is considered, yet its implantation is in body of jaw and not alveolus, and the soft tissues surrounding it posteriorly are not gum, strictly speaking, but epithelium covering some loose connective tissue which separates it from the periosteum. There may be a flap of mucous membrane covering the posterior cusps, or if they are uncovered, there is always a deep developmental pocket behind them. Both of these conditions promote stagnation and infection always occurs. If the flap gets ulcerated from the bite of the opposing teeth infection occurs more rapidly. In any case a localized inflammatory focus arises with a tendency to spread. This area is a common one for the origin of an acute infective gingivitis, either streptococcal or fusospirillary. I have recently seen two acute cases of Vincent's angina originating in this area. If an impaction occurs there is always infection if any part of the crown is exposed in the mouth. Every such tooth I have removed shows evidence of a chronic periodontitis, and the infection must have passed in from the gum margin. In the maxilla, the third molar when displaced by a deficiency of alveolar development tends to erupt external to the arch with its occlusal surface facing posteroexternally. It is usually functionless. There is usually a gingival pocket which develops soon after eruption.

Traumatic occlusion is very commonly associated with malocclusion, and is an important factor in the production of a chronic periodontitis of a very intractable nature. It is seen most commonly in cases of postnormal occlusion with marked overbite and a secondary superior protrusion or retrusion. In these cases contact is made between the mandibular incisors and the cingula of the maxillary incisors, or the gum margin, before the molar articulation is obtained. Thus, at frequently recurring intervals, the whole force of the bite is taken on a limited area; a lateral strain is produced on the periodontal membranes of the maxillary tooth, or the gingival margin is directly damaged. There is always a thickening of these membranes—well shown in radiograms—and even if the gum margin is not directly damaged it becomes involved secondarily by a spread of inflammation. It is only a short time before such chronically congested tissues become infected.

The results of traumatic occlusion are periodically seen in connection with individual teeth. One mandibular incisor tooth is frequently displaced anteriorly and articulates edge to edge with the maxillary incisors, the rest being more or less normally placed. Here one sees a strictly localized recession of the gum due to atrophy of the membrane and absorption of the alveolus. There is also a pocket anteriorly which is infected, as shown by the congested venules leading from this area. General crowding of the teeth in their arches frequently results in their being packed too tightly together. This is usually seen at two definite periods during the years of eruption of the permanent teeth, and may persist or pass off when the eruption is complete. The first period is between the ages of eleven and thirteen, when the canine tooth is erupting. In these cases the arch is not quite large enough to accommodate

all the teeth developed for it, yet not quite small enough to cause the extrusion from the arch of the last erupted tooth. The result is that the canine (usually erupting after the premolars, although the same argument holds good if the second premolar erupts after the canine) comes into an apparently good position. To do so, the premolars are pressed back against the first molar, which cannot give way because of the erupting second molar behind it, and the lateral incisor is rotated. This pressure involves the membranes and gingivae, and in the latter one can see the results. It becomes hyperemic and swollen, the trough becomes deeper and there is a definite exudate. This results in a short time in the deposition of seruminal calculus and infection of the tissues.

The second occasion on which this type of traumatic gingivitis may arise is when the third molars are erupting in the mandible. As these teeth erupt forward and upward, there is always a tendency for pressure to occur on the back of the second molars. If as occurs in so many cases, the amount of room available for this tooth is limited, this pressure becomes excessive. In many cases the first and second molars actually move forward. If contact points are well established the results of this pressure can be seen as far forward as the canine teeth in congested papillae. If there is only a very slight limitation of space the pressure may be relieved when the tooth is fully erupted and in a vertical position.

A case I have recently been seeing exemplifies very well this forward movement of the first and second molars on the approaching eruption of the third. Since 1921 I have been watching food packing spaces between the first and second premolar and first molar for the onset of caries, in a girl then aged fourteen. Last month when I saw her these spaces had completely closed and the contacts were well established, and there was a fulness behind the second molar suggestive of the near presence of the third molar. The girl had well-developed arches and normal occlusion. From the clinical appearances I expect this molar will erupt fully and without much difficulty.

Many of these notes I have made may be considered more as statements of opinion rather than of fact, and I therefore give the following conclusions I have drawn from them with a certain amount of hesitation:

1. Wherever teeth are misplaced a very important predisposing cause of gingivitis is established.

2. The nearer the misplaced teeth are to the ends of the arches, the stronger is this predisposition.

3. That misplaced or impacted third molars—especially in a short arch—are the most important in this respect.

4. That the modern well-developed mandible does not allow of perfectly normal relationship between the third molar and its surrounding soft parts.

5. That, among other orthodontic requirements, treatment of malocclusion should be directed towards the establishment of this tooth in normal relationship with its surroundings, by making room for its anterior translation before, or during eruption. Or alternatively that orthodontic cases should be finally completed by the removal of these teeth.

DISCUSSION

The President said that Mr. Pritchard had opened up a subject which he thought was quite new to the Society, and one which was undoubtedly of great importance. Orthodontists had perhaps been used to being told that their appliances were a cause of gingivitis, but it could be seen now that there were many other causes and the author had enlightened the meeting in regard to some of them.

Mr. J. H. Badcock said that any change in or any malposition of the teeth which led to any particles being in the gum margin tended towards gingivitis. He agreed that if a wisdom tooth was unerupted, especially if malposed, and if there was an opening to the tooth all the surrounding parts were likely to become infected. He did not know that he could go quite so far as the author. It seemed to him that the statement that inflammation of the dental periosteum was caused by natural pressure was highly speculative, and personally he had not met with that condition, or if he had met with it he had not understood it. It was, of course, a very interesting speculation. If it was true it was certainly worthy of notice. He did not understand the distinction which Mr. Pritchard drew between traumatic occlusion and malocclusion. It seemed to him that it was quite possible that if a tooth was so misplaced that it received stress in a way in which it was not intended to receive it, certain changes would occur in the socket surrounding it and in its own cementum. He should have imagined that such changes were rather of a physiologic than a pathologic nature.

Mr. A. T. Pitts said the subject was very closely related to the aims and objects of the Society, and he thought the paper was a masterpiece with not a single word wasted. There were many interesting points in it. He was naturally in agreement with Mr. Pritchard with regard to the food packing following malocclusion, yet it was quite surprising that from time to time one saw cases of very marked malocclusion in adults, often adults approaching middle age, in which the gums were exceedingly healthy. He had several patients in mind who came to see him and he was always amazed to notice that the gum margins were normal and with no signs of gingivitis or pyorrhea, and yet their mouths were so crowded that it seemed to him to be remarkable. He believed that in such cases of gingivitis and pyorrhea, local factors alone were not always sufficient; he believed there were some other causes either connected with the structure or the bone or a deficiency of the masticatory process, which acting in cooperation with the malocclusion produces gingivitis. There was one interesting class of case he had seen that Mr. Pritchard did not allude to, although no doubt he had seen cases. He himself had seen quite a number of cases in which usually the upper incisors were inside the bite, perhaps an upper incisor being twisted round so that when the mouth was closed the upper incisor bit down between two lower incisors and acted like a wedge, forcing one of them lingually and the other labially. In all the cases he had seen there was a localized destruction or gum and periodontal membrane, sometimes extending as much as a quarter of the way down the root. That was an example of what might be called traumatic occlusion causing pyorrhea. The only thing he could suggest was that the forcing of the lower incisor labially thinned the tissue over it to such an extent that atrophy of the gum and periodontal membrane occurred. The incisors forced lingually usually had showed a normal gum margin. He was very pleased to hear what Mr. Pritchard had said about the third molar. Some years ago he had read a paper on the prophylactic extraction of the third molar, a paper which was very coldly received and criticized. He had pointed out that quite apart from actual impaction or misplacement there were a large number of cases in which the third molar looked to be in normal occlusion with the maxillary molar, but in its relationship to the soft tissues it was abnormal in that the gingival margin was abnormally deep and the normal denudation had not occurred, the result being that a chronic infected condition occurred around the tooth. He had seen a large number of cases in which chronic infection occurred, which was quiescent at times and at other times active. He believed such cases were very often the starting point of acute ulcerative stomatitis, and often of pyorrhea. He remembered a case of a girl who was having mercurial injections for syphilis and had developed mercurial stomatitis, and it was possible to see that the infection had started round a third molar which was not impacted and not misplaced, but the gum all round it was practically on a level with the surface of the crown. The ulcerated condition had commenced in that region showing that it was due to lowered resistance. Per-

haps it would be advisable, if the patient would consent, always to try and remove the third molars, except in those cases where anterior teeth had been lost and the third molar moved forward into position. With regard to traumatic occlusion and its relation to pyorrhea, much had been written about the subject and it had been asserted that even where the occlusion appeared to be normal the cusps might be too long or the fissures too deep, and that it could only be detected by means of articulating paper. Such a condition might be a cause of pyorrhea, but he had not found evidence for that view and he should like to hear the views of others.

Mr. Livingston asked the author if he had taken very many radiograms of the cases, and whether he generally regarded the dark line or the absence of shadow of the periodontal membrane detrimental to diagnosis. He did not think it would be safe to take a complete radiogram of the survey of the mouth and take out the dark lines and say that the teeth were suffering from traumatic occlusion or periodontitis. That had been overdone, and he believed it was started in America. He did not think Mr. Pitts had enlarged sufficiently on the very general resistance of the patients to such conditions. He thought a large factor and one that was often not sufficiently considered, was that the general tone of the patient, the tone of their alimentary tract more particularly, had its reflex almost immediately in the mouth. Conditions of lowered resistance associated even with a small degree of malocclusion would produce a large amount of gingivitis, whilst the healthy child and adult, with a large amount of malocclusion but good general tone, would remain quite free. He thought that point required a good deal more elaboration by orthodontists.

The President said the paper had brought to his mind two children whom he had seen recently. It had been suggested by previous speakers that the forms which gingivitis could take appeared to be innumerable. One child he had seen for some years had an excessive overbite for which it was being treated, not as successfully as he would have wished, entirely with plates, and there was a tendency to hypertrophy of the gums. It had always seemed to be high, especially on the mandibular incisors, so that there was comparatively a small amount of tooth showing. He had seen the girl the other day, and on the labial surface of the two mandibular incisors, about two or three millimeters below the free edge of the gum, there was a complete erosion of the gum tissue showing the enamel below. It was the first time he had seen such a condition, and he sent the girl to a dentist to have the teeth scaled although they were not teeth that might be described as unusually dirty. Another case recalled to him was that of a child, where the gum over the six maxillary fronts was of a peculiarly bright pink, almost bright red. The child, which he had known about six months, struck him always as an exceedingly delicate child. She had returned from her summer holidays looking no better than when she went away. She was going to school in the country where he hoped her health would be improved, but he felt so strongly about the matter that he was almost taking it upon himself to advise that she should see a physician for treatment. It was quite possible that such a case came under those which Dr. Livingston had referred to, and it did seem that cases of gingivitis were of innumerable descriptions. The members were very much indebted to Mr. Pritchard for his very valuable paper. If it were possible to obtain enlightenment on the treatment of the conditions it would be of very great help.

Mr. Pritchard, in reply, said that with regard to Mr. Badcock's remarks expressing doubts as to pressure causing definite inflammation he did not actually suggest that, but was trying to suggest that the pressure, of an erupting third molar, for instance, as a result of its translation forward, through the teeth and on to the membranes and interdental papillae, rather interfered with the normal circulation passing through those tissues, causing possibly an increase in blood supply or a deficiency in blood supply. His point was that the alteration in the circulation rather lowered the tissue resistance, rendering it much more prone to pick up any infection that might be in the mouth than if the altered circulation had not been present. With regard to traumatic occlusion and malocclusion, he did not think they were synonymous. Apparently many cases of malocclusion could occur without there being any traumatic occlusion. By traumatic occlusion he rather meant the absence of the simultaneous contact of the planes of the maxillary and mandibular teeth as they came into occlusion. Another example was the occlusion of the mandibular incisors with the maxillary incisors before

the molars had definitely met, thus allowing direct pressure which caused lateral stress on the teeth before the actual stress of the bite had been taken by the molars. Many of the speakers had dwelt on the possibilities of gingivitis associated with pyorrhea not being entirely a disease of local origin. That was a very well-established fact, he thought, because many cases cropped up where a patient had all the conditions which strongly predisposed to the onset of a marginal infection of the gum yet escaped, whereas others without those predisposing causes would start pyorrhea which would continue in spite of treatment. Undoubtedly other things besides local conditions in the mouth could bring about preliminary degeneration of the membranes of the teeth, thus allowing them to get infected. With regard to the radiographic dark line and traumatic occlusion, he was rather working the other way from that which Dr. Livingston had suggested. If one took x-ray photographs of teeth which were definitely suffering from traumatic occlusion (for instance, in an extreme case if the posterior teeth were out and the mandibular incisors biting on the maxillary incisors caused a general loosening of the teeth), the dark line of an area was considerably widened, and associated with that there was a marked diminution of the sharp white line of the lamina dura, and there being an absorption of the compact bone, there was a thickening of the membrane, and in every case of that kind the condition was examined radiographically. The chronic hypertrophic conditions of the gum seen in overbite he believed to be one of the manifestations of infection of the gum margin. The infection could take on a variety of types. There could be an acute, active ulceration of the gum margin, with rapid disappearance of the dental papillae and stripping of the root. There was also a milder condition where there was a definite fibrosis. If an enlargement had occurred to such an extent as to give rise to what might be termed a false pocket between the gum margin and the normal surface a close examination would often show a minute amount of ulceration.

On the motion of the President a hearty vote of thanks was accorded to the readers of short communications, and the author of the paper. In order to facilitate the use of the museum and library, the Council had thought it wise to appoint an Assistant Librarian and Curator, and Miss Violet H. George had undertaken to fulfil those duties. The Society had received a cordial invitation for any or all of the members to attend the International Orthodontic Congress in New York on August 16th to 21st, 1926. That was the week immediately preceding the week of the International Dental Conference in Philadelphia, so that the members attending one could attend the other. The British Society was a component part of the Congress, and the members were all entitled to attend. That, however, did not entitle them to receive a copy of the *Transactions*, and to obtain this it was necessary for each person requiring it to become a member of the Congress. The members of the Society had also been invited to read papers or present communications to the Congress and he was certain any contributions would be welcomed.

SOME USES OF AUXILIARY SPRINGS IN CONJUNCTION WITH LABIAL ARCHES*

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IN BRINGING this subject before you for consideration this evening, I am well aware that it has often been gone into quite extensively, and therefore I fear that I will have nothing very original to offer you. I will, however, endeavor to throw a little light and put some order in what I consider one of the most confused and unsettled parts of our technic. I would like to bring to your attention a few points in connection with the use of auxiliary springs; let us, therefore, try to analyze more closely than is usually done the purpose for which these springs are used—namely individual tooth movement—their method of construction, and their application to a few concrete cases. A problem correctly stated is half solved, as the saying has it, so let us examine the problem set to us by any orthodontic case. Our aim being to take an underdeveloped mouth, with probably a crowded arch, and possibly malrelation of the jaws, and make this into a properly proportioned face, with correct functional and esthetic balance of both soft and hard tissues, what varieties of movement will have to be accomplished before our result is attained? We will be called upon, first, to properly develop the under-developed jaw bones; second, to correct their malrelation; third, to properly train the facial muscles, and lastly to attend to individual tooth movements. All of these partial corrections may possibly be carried on simultaneously, but their study requires separate consideration: the three first points have nothing to do with the subject of this paper, so we will dismiss them entirely, to devote our attention to the various elementary movements of the teeth, and the methods and means of obtaining them.

DIFFERENT VARIETIES OF ELEMENTARY TOOTH MOVEMENT

Numerous authors have described the many possible movements of any tooth, but a careful and scientific examination of facts will bring you to realize that, mathematically, all tooth movements may be reduced to two elementary varieties: a tooth may be moved *around* one of its three principal axes, or its displacement may be *parallel* to one of them. There is no other possible tooth movement.

I will now take the liberty of defining certain terms which I will use in the course of this paper, so as to avoid misunderstandings.

Rotation (L. *rotatio*).—A movement around the long axis of a tooth. Rotation of any given tooth is defined by stating (1) the angle of the tooth considered, (2) the direction in which this angle is displaced. For instance we

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would speak of a mesiolingual rotation of a central incisor, meaning that the mesial angle of the tooth is turned in a lingual direction, which from a mathematic standpoint could equally well be called a distolabial rotation, since a

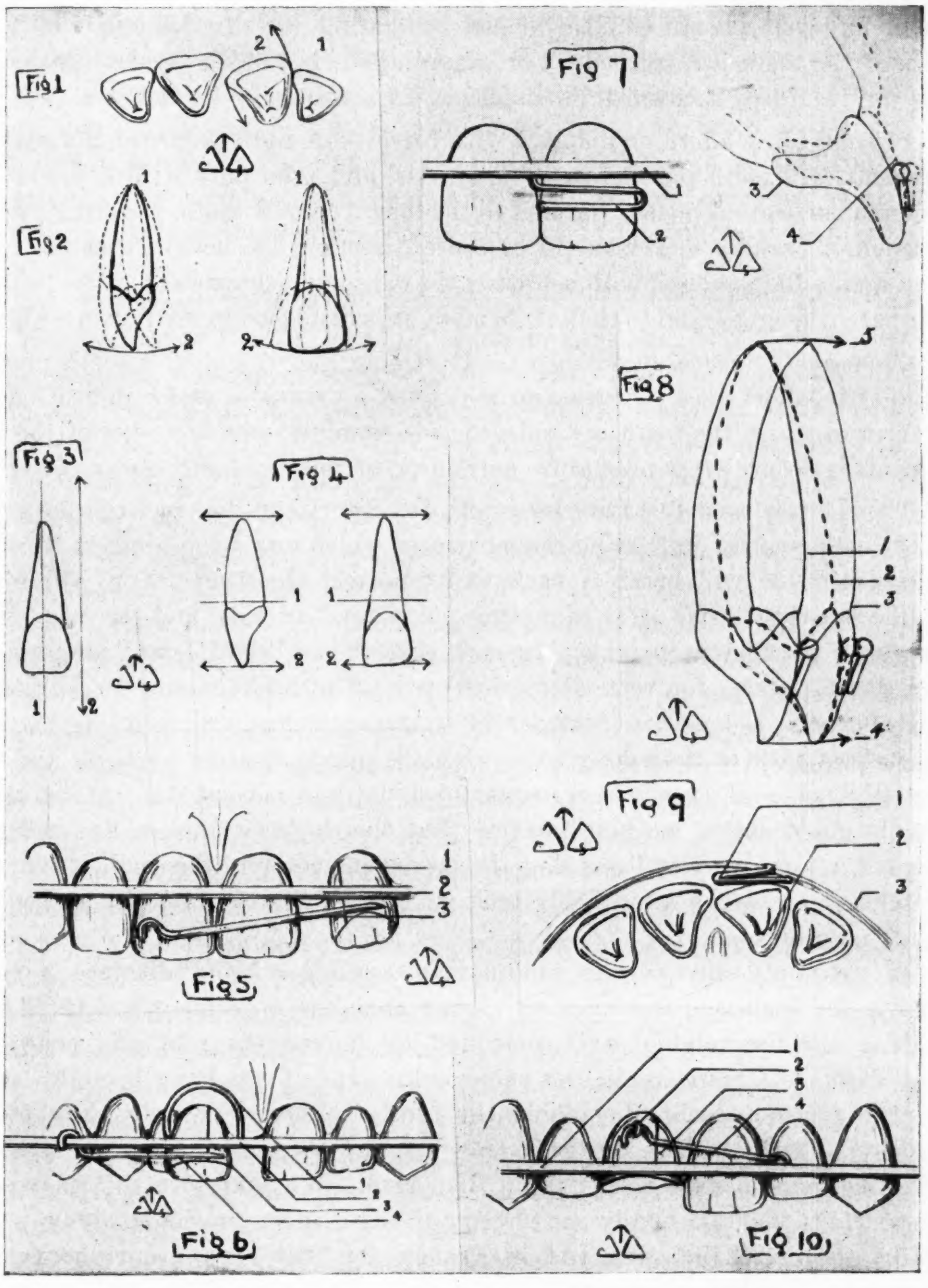

Fig. 1.—Rotation. (1) axis of rotation, (2) direction of displacement. Fig. 2.—Versions: (1) axis of versions, (2) direction of displacement. Fig. 3.—Trusions: (1) axis of tooth, (2) direction of displacement. Fig. 4.—Gressions: (1) axis of teeth, (2) direction of displacement. Fig. 5.—Appliance for mesioversion. (1) band, (2) arch, (3) auxiliary spring on band. Fig. 6.—Appliance for mesiogression: (1) auxiliary spring on arch, (2) arch, (3) band, (4) auxiliary spring on band. Fig. 7.—Appliance for linguoversion: (1) arch, (2) auxiliary spring, (3) primitive position of tooth, (4) final position of tooth. Fig. 8.—Appliance for labiogression: (1) primitive position of tooth, (2) intermediate position, (3) final position of tooth. (4) primary movement of tooth, (5) secondary movement of tooth. Fig. 9.—Appliance for rotation: (1) auxiliary spring on arch, (2) rotated tooth, (3) arch. Fig. 10.—Appliance for extrusion: (1) arch, (2) bracket on band, (3) band, (4) auxiliary spring on arch.

rotation of one angle around the long axis must needs have its counterpart at the opposite angle (Fig. 1).

Version (L. *vertere,* to turn).—A movement around one of the short axes of a tooth, namely, the mesiodistal or the linguobuccal (or linguolabial). Version of any given tooth can be defined by stating the direction in which the crown of the tooth is displaced. For example: when a molar used as anchorage gives way, and tips backward, its displacement is termed a distoversion (Fig. 2).

Trusion (L. *trudere,* to displace with force).—A radical, meaning a vertical movement of a tooth parallel to its long axis, and used only with a prefix: *in*-trusion, a vertical movement parallel to the long axis of a tooth, toward its apex; *ex*trusion, a parallel movement in opposite direction, i.e., away from the apex. When a maxillary incisor with a broken tip is brought downward, so as to make its apparent length equal to that of its mate, it is displaced by extrusion (Fig. 3).

Gression (L. *gradi,* to advance).—Horizontal movement of a tooth parallel to one of its short axes. A gression is defined by using a prefix indicating the direction in which the tooth is displaced; for example, mesiogression of the first molar often occurs after premature extraction of the deciduous molars (Fig. 4).

These terms, as defined are used both for describing the condition of a misplaced tooth, and for indicating the movement which may have brought it to this false position or will bring it back to its normal situation. You will notice that the two first terms refer to movements around an axis, and the two last to movements parallel to an axis. In each case it has been deemed advisable to use a separate term for vertical movements, and a different one for horizontal displacements. Let us now consider for instance an incisor tooth; we may describe three axes to it: a long axis, which is approximately vertical, and two short or horizontal axes, which are labiolingual and mesiodistal. If, as in the example given above, we now imagine that this tooth is broken and must be *extruded,* we can very well see that the movement accomplished will be parallel to its long axis. The same holds true, of course, for the opposite movement, were it necessary.

If we apply any of the root-moving appliances, and displace a tooth labially, for instance, it stands to reason that the movement produced will be along the linguolabial axis, provided we moved the root and crown an equal distance. Here again the same holds true if we have brought about the contrary movement, displacing the tooth lingually. Finally, any bodily movement along the line of the arch must, for the same reason, be parallel to the mesiodistal axis of the tooth displaced. We therefore see, as was to be expected, that all bodily movement of teeth must be made along a line parallel to one of the axes, and in France, for that reason, such movement is termed "parallel movement," for each axis continually remains parallel to its previous position. Now, considering again the movement around one of the axes of the tooth, it should be borne in mind that the actual center of rotation may not coincide with this axis, but may simply be parallel with it, as we can determine neither the exact center of rotation of a tooth, nor the exact location of any one of its axes. These circular movements we will term *rotations,* when they take place around a vertical axis, and *versions* when

the tooth revolves around a horizontal axis. Thus a tooth placed in what Angle terms "torsoocclusion" is simply rotated around its long axis; likewise, a molar which is tipped buccally through excessive stress from an appliance is in buccoversion, and the treatment which corrects it will of course be a linguoversion. Any two of the above movements may exist, or be carried on at the same time, provided they are not contrary in direction: one of them may be a parallel movement and the other may be a circular one, or both may be of the same type. In fact it is quite usual that any tooth movement is a combination of two or more of the elementary movements, so that most tooth movements are complex, and composed of a greater or lesser number of elementary movements, and are rarely reduced to one single elementary form.

AUXILIARY SPRINGS AS USED IN CONJUNCTION WITH LABIAL ARCHES

My first conception of auxiliary springs used with labial arches was intended to allow rotation of teeth without bands. Many authors have tried to attain this result with various mechanical devices, usually consisting of double arches, lingual and labial, and different means of exerting pressure: ligatures, as in the appliance of L. Ruppe, or springs, as in J. Lowe Young's, Pullen's, H. Chapman's and my own. It is therefore by no means a new idea. However, results obtained have more often than not been mostly theoretic, and hardly, if at all, practical. Most of the authors have, for various reasons abandoned their methods, particularly on account of the uncertainty of the results obtained, and of the difficulty of keeping their devices in permanent and active contact with the teeth to be moved. I do not pretend to have solved the problem, but I consider that in certain cases springs can be used without bands, while in others they cannot. Rotations of incisors around a vertical axis, versions around the mesiodistal axis, certain versions around the labiolingual axis, and intrusions can usually be obtained without bands. However, rotations of canines and premolars, some versions, most extrusions, a few intrusions and mesial or distal parallel movements, make necessary the use of bands. It should be understood at the outset that auxiliary springs, as used in connection with labial arches, differ from those used on lingual arches, both in construction and in size. Those who are familiar with lingual arch technic will remember that auxiliary springs in such cases are made of the finest and toughest platinum-gold alloy. They are made of very small gauge wire because lingual arch technic requires the visits to the orthodontist to be at least two months apart. Labial arch technic, on the contrary, calls for more frequent visits and promotes more rapid results. Moreover, as the auxiliary springs in this case are used only for individual tooth movements and not for general expansion of the dental arch, or bone growth, there is no reason for making them long and delicate, as with the lingual appliance.

I should point out also that the auxiliary springs used for individual tooth movements may, according to cases, be attached either to the arch itself, or to the tooth, by means of a band. This naturally depends upon the movements required, the first essential being to keep the active portion of the spring as nearly parallel to the arch as practicable, the second being to avoid any cumbersome attachments, the third to have the wire as resilient

as possible, and the fourth to maintain permanent contact between the active portion of the spring and the tooth. One of the principal advantages I have found in the use of these springs resides in the possibility of obtaining a more permanent action of the appliance, by making use of a continuous force, thus allowing patients to remain away longer, feeling certain that the action of the spring will not stop for some time, and that patients will not suffer from soreness of the teeth. Soreness is commonly produced by intermittent and too rapid action. If we use springs to regulate the movement of the teeth we obtain a continuous action, and the spring transforms the otherwise rapid action of the ligature into a much slower one. Auxiliary springs may be used in two opposite manners: (1) for direct and positive transmission of force, and (2) as a brake, so to speak, to slacken or arrest movement in a given direction and transform it into movement in another direction. Both of these uses may be combined advantageously to act upon single teeth, particularly when parallel movement is to be obtained. It is well known that purely parallel movement is seldom, if ever, accomplished; usually the effect of such appliances as the "Ribbon arch," or similar ones, is to first produce a tipping, or more exactly a version of the tooth, then, through the force of torsion of the appliance, to produce a second version in the opposite direction, so that first one extremity of the tooth, then the other, is advanced in turn, and gradually brought into position; the tooth thus advances more rapidly than it could were it rigidly held in an appliance that could produce only purely parallel movement, such as Case's "contour appliance."

CONSTRUCTION OF AUXILIARY SPRINGS

As previously mentioned, springs may be attached to the labial arch directly, or to bands upon the teeth. In this case, comparatively light and very resilient wire should be used, as the spring must be long enough to have considerable leverage, and light enough not to exert too much force and damage either to the peridental membrane or the pulp. For this purpose I use gold-platinum retaining wire manufactured by the S. S. White Company, of exactly the same composition as is used for lingual appliances. This material provides a very good force for all movements. When used on bands, the spring is soldered in whatever position desired, care being taken to place it where it will not come into contact with the arch, and to leave it sufficiently long to give a good leverage; it may conveniently terminate in a small hook or loop opposite the next tooth but one.

(1) If, for instance, a mesioversion of, say, the left lateral incisor is desired, the tooth would be banded and the spring soldered to the band would extend over mesially as far as the right central incisor; it would consist of a plain wire 0.55 or 0.63 mm. in diameter, ending in a hook or loop. The wire would be placed at right angles to the long axis of the tooth and therefore it would not lie exactly parallel to the arch, but diagonally towards the incisal edges of the teeth (Fig. 5). Two methods can be used to connect the spring with the arch: (1) it may be attached directly by means of the hook which terminates the free end, or (2) it may be secured by means of a ligature. I have found it more convenient, as a rule, to place the springs near the incisal

edges of the bands rather than at the gingival border, so as to avoid traumatism to the gum. Of course, if the opposite movement were desired, namely, a distoversion, the spring would be directed towards the premolars instead of the centrals.

(2) Let us now consider the case of a mesio- or a distogression. We would band the tooth to be moved, and as the movement to be obtained is a parallel movement the spring from the band should be as nearly parallel to the arch as possible, and should terminate in a hook so as to obtain a more fixed attachment to the arch. The next step would be to solder to the arch an auxiliary spring, which we can conveniently form into a loop extending gingivally and ending in a finger which will gently, but firmly, press the tooth in the desired direction. The spring on the band could be a 0.55 or a 0.63 mm. wire (B. and S. gauges 23½ and 22 respectively), and the one on the arch a 0.63 or a 0.76 mm. (B. and S. gauge 20½), the arch itself being a 1 mm. (B. and S. gauge 18) wire (Fig. 6). Now, when our arch spring applies force to the tooth, it simply produces a mesio- or distoversion, as the case may be; and in so doing it also bends the spring on the band, which is considerably smaller, until a balance between both these forces is established. Then, as each spring continues to exert its force, the arch spring very rapidly becomes less active for, being the stronger of the two, it spends all its force and reaches its position of rest before the smaller one; finally the smaller spring attached to the band continues its work and rights the tooth without interfering with its position, which is maintained by the arch spring. If, at the end of this time, the desired position is attained, well and good; if not, the arch spring is tightened again and the tooth is displaced a second time in a similar manner. In short, as you see, mesial or distal displacement, whether it be by version or parallel movement, can best be accomplished by banding the tooth and extending from the band a spring to be attached to the arch. In one case this spring does all the work, and in the other it serves as an adjuvant or corrective to the principal spring attached to the arch.

(3) Horizontal displacement in a direction perpendicular to the arch, labially or lingually, does not as a rule require the use of bands. It is usually sufficient to attach a spring to the arch, using a 0.63 mm. (B. and S. gauge 22) wire. The shape of the spring is rather particular, and is designed to give it as much resilience as possible. This result is obtained by soldering the wire perpendicular to the arch, in the vertical plane, and bending it sharply at 90° to make it lie along the arch, and about 1 mm. from it. Then, at a proper distance it is bent back sharply at 180° and made to lie parallel to the arch again and about 2 or 3 mm. from it. This double bending will bring back most of the temper taken out of the wire by soldering. The wire, after its second bend, constitutes the spring which is to direct the movement of the tooth. It should therefore be brought into such a position that it will act upon the tooth in the desired direction. The tooth is then ligated to the arch and the spring will regulate the movement of the tooth (Fig. 7). If the movement is to be a labioversion no spring is necessary, and the ligature alone suffices. If the movement is to be a linguoversion the spring should not at

once be given its final position, but only an intermediate one, so that the action will be gentle.

(4) If the movement is to be a labiogression the spring should press lightly on the *labial* side of the tooth. When the ligature is tightened the spring also is tightened, *ipso facto* but as its point of contact with the tooth is much nearer the incisal edge it will promote root movement by its lever action. The result will be first a labioversion, through tightening of the ligature, then, as the force of the ligature is almost spent, the spring, in its turn, exerts a continuous pressure which slowly and steadily rights the tooth (Fig. 8). I have never found occasion to perform the opposite movement, linguogression, with these springs, and will not, therefore, describe any appliance that I have not used myself, but it would be easy to devise one. We have passed in review all of the movements of the teeth around horizontal axes, or parallel to them. Let us now examine rotations and vertical parallel movements.

(5) Rotations of the four anterior teeth can be accomplished by means of springs without the use of bands. Canines and premolars are best rotated by the usual methods. In the case of canines, springs may be used as well as bands to help the rotation, but for premolars their usefulness is not as yet demonstrated. The spring, in this case, is a 0.63 mm. (B. and S. gauge 22) wire attached to the arch and shaped by a double bend, just as previously explained (Fig. 7), the free end resting close to the outstanding corner of the tooth to be rotated. If the tooth is also somewhat lingual to normal the rotation will usually be more easily accomplished (Fig. 9).

(6) Vertical movements of the teeth, intrusion and extrusion are accomplished by the use of a spring soldered to the arch. It is well to use a rather light wire, such as 0.55 mm. (B. and S. gauge 24) for extrusion, and a stronger one such as 0.63 mm. (B. and S. gauge 22) for intrusion. The tooth is usually banded, and the band carries near its edge a bracket or spur, in which the spring will engage. The spring is soldered to the arch in a vertical plane bent in a half circle about 2 mm. in diameter, and bent again sharply to lie along the arch. It should be attached sufficiently far from the tooth to be moved to allow it to be resilient and not too powerful. It terminates in a hook which engages in the bracket on the band. Before placing the appliance in position in the mouth the spring is bent so as to exert the proper force in the proper direction (Fig. 10). Intrusion movement may be obtained without banding the tooth by hooking the spring around the incisal edge of the tooth, but the use of a band is usually to be recommended.

As has been explained, the use of these auxiliary springs in conjunction with labial arches is intended only for individual tooth movements, usually after expansion has been successfully accomplished, or in such cases where little or no expansion is demanded. This does in no manner preclude the possibility of expanding the arch with the same appliance as used for individual tooth movement, and at the same time.

Having explained the theory of auxiliary springs, I will now show a few cases in which I have used them to some advantage. In the following illustrations the appliances are shown upon casts of the teeth after treatment. The other casts show the condition before any appliance was put on.

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DISCUSSION

The President said that Dr. Quintero had presented a very excellent paper. He had discussed his subject from the theoretic and the practical point of view and shown the application of all his theories. He invited discussion.

Mr. Highton thanked Dr. Quintero for all the instruction and information he had given, and for pointing out so carefully the different forms of tooth movement and the nomenclature of the various movements brought about. He was interested in what Dr. Quintero said about extrusions. He wondered whether in bringing the teeth into position he had to retain them for any length of time, and if so what length of time he found necessary, and if even after retention there was not a tendency to relapse. Dr. Quintero had shown several cases with a certain amount of expansion. He took it that Dr. Quintero used a lingual arch and he wondered whether he found it necessary to use accessory springs on the lingual arch in conjunction with the buccal arch to accomplish some of the movements referred to. Apparently a great deal of movement could be brought about rapidly with accessory springs on the buccal arch, but he would like to know whether it was necessary to retain those teeth at all or whether Dr. Quintero allowed the auxiliary spring itself to form a retainer for the time being. Dr. Mershon, who was in London last June, suggested the use of rest periods when using

lingual arches. He did not suppose they were necessary for the treatment of the cases referred to by Dr. Quintero, but wondered if Dr. Quintero had ever abandoned movement for a time and adopted rest periods or whether he always used continuous movement. It was stated that a small amount of tension was put on the accessory springs in the first place. He would be grateful if Dr. Quintero could state definitely the amount of tension which he actually used at various periods.

Dr. Quintero said that was largely a matter of practice.

Mr. Norman Bennett said he had been particularly struck by the ingenuity of the arrangement for producing what Dr. Case called many years ago a bodily tooth movement, but what he himself would prefer to term a movement of translation into a position parallel with the original axes. The plan suggested by Dr. Case years ago was no doubt mechanically correct, but it involved an enormous resistance on the part of the tooth to be moved, a resistance so great that probably the so-called anchorage would come away before the tooth itself was moved. Dr. Quintero, by the ingenious arrangement he suggested in the early part of his lecture, showed how with two springs the second spring only came into operation gradually at the time when the first spring was ceasing to act and that it was intensified in its action at a later stage. In that way he produced a sort of see-saw arrangement, the movement of rotation being in one direction first followed by rotation in the other direction, so that the final result brought the tooth into a position parallel with the original axis. That seemed to him highly ingenious and reminded him of the action which he thought everybody employed in using the fissure burr to cut out an amalgam filling. In doing so one did not cut parallel to the direction of the burr but used a see-saw movement and was thus able to get on much quicker than if one went straight ahead. Dr. Quintero got over his resistance not in one go, as it were, but first in one way and then in another and so corrected it. He thought that was highly ingenious.

Mr. Northcroft said it seemed to him one of the points Dr. Quintero brought out was the desirability, which had been so often mentioned before, of having an international nomenclature so that orthodontists in every part of the world could speak the same language. He thought the terms Dr. Quintero used to express the various tooth movements that were required, having in view the fact that those terms explained the positions of the teeth as well and that they were universally used in France, were certainly desirable ones, and might very well come before the attention of the Society's own Nomenclature Committee. One point in regard to which he would like further elucidation was as to when Dr. Quintero used auxiliary springs on the labial arch—whether when he used horizontal tubes on the molars he was careful to lock the maxillary arch to those molar teeth or not. It was obviously not necessary when a vertical tube was used on the molar teeth to do so, but if the arch working in horizontal tubes was not locked in some way a great deal of the resilience of the auxiliary springs must necessarily be lost. He would welcome further elucidation of that point as it was not brought out very clearly in the paper.

Mr. Friel wished to join with other speakers in thanking Dr. Quintero for coming so far to give the members the opportunity of listening to his excellent paper. It was of great benefit to orthodontists when the facts referring to any branch of orthodontics were placed in orderly sequence and that was what Dr. Quintero had done. He could not say that he was altogether in agreement with Dr. Quintero on the reasons for using thicker auxiliary springs on a labial arch than on a lingual arch. He understood Dr. Quintero to say that it was because one did not require bone growth; but if one moved a tooth at all one must get absorption and reformation of bone, and surely that was bone growth. He quite agreed with Dr. Quintero that thicker springs must be used, but his own reason for their use was different. His reason was that it was not so difficult to keep an auxiliary labial spring in place. The movement of the lips in mastication moved the spring about, and though a weak spring was desirable it could not be used. He would like to ask Dr. Quintero how often the ligatures had to be altered in those cases, because his own experience was that if one did not alter ligatures fairly frequently one got a stain on the enamel from a brass ligature which was very difficult to remove, and which it was difficult to persuade the patient was not caries. His only objection to labial springs attached to labial arches, and especially those springs that were parallel with and close to the labial arch, was that they were so difficult to keep clean. The area that was covered by the

wire arch and the spring was so wide that the ordinary movement caused by the toothbrush did not expose the whole area to be cleaned, and one was very liable to get decalcification of the teeth underneath the spring and arch.

Mr. Watkin wished to associate himself entirely with Mr. Norman Bennett's remarks. He had come from Liverpool to hear the paper, and he would go back content even if he had only learned one of the things that Dr. Quintero mentioned, namely, that relating to the use of two different springs of different strengths.

Mr. Cale Matthews said that there was just one point which when reading the paper over he felt some anxiety about, and that was that apparently Dr. Quintero was going to add very many more difficulties to those which already oppressed people who were engaged in teaching the subject of orthodontics owing to the coining of new words, but since he had heard the paper read and had followed it through he realized that there was something very important in those terms that Dr. Quintero used. In regard to one sentence in the paper he would like to sound a note of warning, and that was in regard to the period of time between inspections by the orthodontist. In the last few years there had been great enthusiasm for metal arches. He defined them in that way because they were applied as lingual arches and as buccal arches. It was being taught very largely that one might send patients who had been fitted with them away for months without attention. Whatever the results might be from a purely tooth-moving point of view, he could not but deprecate that most sincerely. He thought it was dangerous to send patients away for months with appliances in their mouths. Damage was bound to occur to the tooth structure under the ordinary conditions in which children lived and were looked after. Such ideas were all very well in the case of a skilled orthodontist who had every preparation made with his appliance, but the discussions which took place and the papers which were read before the Society were followed by all the younger members of the profession who were now taking up orthodontic work, and they might infer that they could take a much greater liberty with their appliances than they were in fact justified in doing. That was the only criticism he had to offer, and it was not so much a criticism of Dr. Quintero's paper as of a tendency which was so prevalent today, to think that modern orthodontic appliances mainly looked after themselves.

Mr. Maxwell Stephens emphasized the point raised as to caries arising in connection with the accumulations which must occur about the springs. There was another point he would like to mention, and that was in regard to the case which Dr. Quintero had mentioned that the President had asked him to show. He would like to know what time was occupied in the movement of the teeth into the central position and also if any experimental radiography was carried out.

Mr. H. E. Marsh said he had only one point to raise, namely, whether in the carrying out of the mesioversion movement in the first appliance shown, where there was a band connected to the tooth with a spring carried forward to the tooth and then raised up to the arch by means of a hook or a ligature, one would ever get extrusion of the tooth as well as mesioversion. It had occurred to him that that lateral was bound to be elongated. He hoped that he was wrong about that because it had struck him as being a very excellent way of carrying out mesioversion.

Mr. Pitts asked if Dr. Quintero could say after he had treated his extrusion cases what was the position at the gum margin. It would almost seem as though there must have been some exposure of the cementum at the neck of the tooth. If the tooth dropped down to the level of its neighbors there must have been complicated changes in the apical region. He would like to know whether he had understood Dr. Quintero correctly to say that one could combine expansion together with the use of those arches, because it seemed to him that arch was being used as a rigid scaffold for the adjustment of the springs, and if one carried out expansion as well one might get changes in the arch which might affect the action of the auxiliary springs.

Mr. Robert Lindsay said that had Dr. Quintero dealt with any of the first three of the four sections into which he divided the whole duty of the orthodontist, he might have had some reason for intervening, because then they would have been on the delightful ground of pure theory where any amount of discussion might take place without harm. Unfortunately

—in one sense—Dr. Quintero confined himself to the one practical section, and therefore naturally he (Mr. Lindsay) felt inclined to leave the discussion to the practical orthodontists present. It appeared—criticizing the discussion and not the paper—that everything Dr. Quintero had said was right. One thing he would say was that the diagrams and the manner in which he explained them were so satisfactory that there was no difficulty in getting at his meaning. It must be a matter of general satisfaction and congratulation that the cases with which Dr. Quintero demonstrated the effects and the application of his theory and of his springs, were so apparently successful. He also, like another listener, had wondered what happened in the apical region of extruded teeth. His friend Mr. Wilson Charles had whispered to him that what was going on there was the interstitial deposit of bone. Mr. Charles had forgotten evidently that the socket of the tooth was a surface and that any deposition which took place in that locality would therefore be surface deposition. Perhaps Dr. Quintero could say what his experience had been in that connection because unless one could get deposition of new bone behind that extruded apex there would surely be retrusion or intrusion and the last stage might be worse than the first. Like Mr. Pitts, he was interested in the question of the gum margin and the possibility of the exposure of a part of the cementum in these cases of extrusion, but he thought Mr. Pitts would agree that exposure of a small part of the cementum would be a very minor calamity compared with the alternative necessity for prosthetic restoration of the point of the tooth. With reference to the very remarkable case which Dr. Quintero showed at the end of his paper, it would have been of great interest if Dr. Quintero could have given the details of the treatment step by step. The actual extent to which the occlusion was restored would hardly have satisfied those who, he understood, held that if between absolutely correct and normal occlusion and what was effected either by restoration, by filling, or other means, there should be one-third of a millimeter of difference, one might ruin not only the health and the dentition of that individual but also his immortal soul.

The President said that before calling on Dr. Quintero to reply, he would like to say that he had been particularly struck with the ingenious way in which Dr. Quintero had been able to tip the incisors. He was not quite sure that it was necessary to have bands in every case, however, in order to do that. He remembered a short time ago removing a lateral in order to get the central over into its place, which, of course, would result in tipping unless there was some special arrangement. Although probably he did get some tipping he averted most of it by means of a spring at the side of the tooth towards the gap—this spring at the tip of the tooth exerted less force than the spring which was employed to move the tooth into the space, and acted on the medial surface near the cervical margin. By this method he obtained the same effect as Dr. Quintero but without a band. It would require a favorable tooth and a favorable patient to use his method, whereas Dr. Quintero's was applicable in every circumstance. He had been a little disappointed that Dr. Quintero had not referred to the high labial arch because personally he had found that in certain cases it was an extremely valuable appliance, especially where he had wanted to get a slight rotation. He had to admit, of course, that it could not usually be used without the lingual arch for that purpose, but one got a very delicate pressure which would go on for a long period and do the work most efficiently. There was only one criticism he had to suggest and he hesitated to do so because Dr. Quintero had told him that he had adopted one of his suggestions recently and found it most difficult to work. The suggestion he now wished to make was of a similar nature, and he therefore had great diffidence in putting it forward, but it did occur to him that if the springs were soldered to the arch instead of to the band, and the fixed point or catch put on the band instead of the arch, the appliance would be simplified greatly in its efficiency, because if the spring broke it could be so easily replaced. Whether that was practicable or not he could not say, not having tried it. The discussion did show, as Mr. Lindsay said, that the members appreciated very much the paper which Dr. Quintero had presented. Their criticisms were really on very minor points, and showed that they had been greatly interested in what Dr. Quintero had said. He thought the audience present that evening was the best evidence the Society could offer to Dr. Quintero of their appreciation of his kindness in coming on so long a journey to give them so excellent a paper.

Dr. Quintero, in reply, thanked all those who had taken part in the discussion. It had been a great pleasure to him, he said, to hear their views, and he highly appreciated the criti-

cisms which had taken place. He feared that most speakers had been too kind to him in their expressions of appreciation for what he had done. He did not think his paper embodied very much original work in spite of what one speaker had said. He had tried to pick out right and left the best things he could find from different authors and transform their ideas to suit his needs, and that was the way in which he came to evolve his ideas of springs on labial arches.

Mr. Highton had asked him if he had experienced relapses in cases of extrusion. One could always, of course, have a relapse in a case of extrusion if the result was not retained long enough. He had always found that extrusion was the hardest and the most difficult of all the movements to retain because, as Mr. Lindsay put it, there is no interstitial bone deposit there; it was only surface growth and it was very slow in coming. A tooth would not remain in a fixed position unless it was in a socket, and that socket did not exist, or unless there was something to hold the apex of the tooth. That was most necessary in cases of extrusion. If one extruded a tooth two or three millimeters it would take two or three millimeters of bone growth at the apical end before that tooth would remain in the position to which it had been brought down, and that bone growth might take at least two years to occur. He had had cases that had been retained for over a year, and when the retainers were taken off the tooth had gone up again and he had had to put on another appliance to do the work over again, which proved that the bone had not been deposited at the apex. If a case of extrusion, though retained for a year, was found to go back, it would be better to retain it for two years and find out if that was enough.

With regard to rest periods with those arches, he was accustomed to see his patients about once a month and tighten or change their ligatures, so that most of the work was done in the first week and they had three weeks of rest. The treatment therefore went on comparatively slowly and without any discomfort to the child.

Mr. Norman Bennett mentioned double rotation around one of the short axes. That action was obtained not only with the springs but also with the ribbon arch. When one tightened a ribbon arch the first thing that happened was that the crown was displaced and displacement of the roots only happened at the end. One got exactly the same kind of double version as one did with the springs; there was practically no difference.

Mr. Northcroft's remarks on nomenclature were very timely, of course. He quite agreed with him that a definite nomenclature was needed. He wished to mention, however, that the terms used in his paper were not of his own invention. French orthodontists had been at work on the problem of nomenclature for at least eighteen years. The first to give attention to it was probably M. de Nevrezé, on his return from America in 1906 or 1907. He proposed a nomenclature and classification of malformations and malocclusions as well as an interesting classification of movements of the teeth. Another nomenclature was introduced by Dr. Frey, a lecturer at the Faculté de Médicine of the University of Paris. Yet others were produced, and finally Frey, Lemière and Villain got together and evolved a nomenclature of which the terms he had used formed only a small part. That nomenclature provided for terms defining all the malpositions of the teeth and the alveolar borders of the maxilla and the relationship of the arches. Finally Izard, about a year ago, gave a synopsis of a nomenclature which seemed to be better than the others, and in which a certain number of terms were omitted. Nearly all those nomenclatures were alike and the terms which he himself employed were found in practically all of them, so that all those French teachers used the same nomenclature in their work in their different schools. Personally he used it in his own work in teaching; the same terms were used all over France.

Mr. Friel had asked about the absorption and formation of bone. Whenever one displaced teeth some bone growth took place, of course, although certain experiments, conducted in 1903 or 1904 by an investigator whose name he had unfortunately forgotten, seemed to show that that was not always the case. The investigator in question mixed some dye into the food of certain animals for a certain number of days and, after the dye had been suppressed from the food, submitted the animal to tooth movement and found that the bone was colored all around the teeth, and that there was not any uncolored bone around the teeth which had been moved which proved there was no production of new bone. The bone, apparently, was simply bent. There did not seem to be any absorption of bone and formation of new bone around the teeth that had been displaced.

He knew that ligatures did stain the teeth. When wire ligatures were left on for a long time, very disagreeable stains were sometimes produced. In some mouths the stains were produced more quickly than in others and were much harder to remove, but in some mouths the ligatures could be left for several months without producing any stain at all. It depended not only on the care taken by the child of its mouth, but on the saliva and the food taken by the child, etc. He usually changed the ligatures about once a month, when he thoroughly cleaned the teeth and removed any stains that might be present to avoid the possibility of caries.

Once in a while he found decalcification of the teeth. He did not know whether decalcification could be attributed absolutely to the appliances or not, because it did not always seem to occur in contact with the appliances. One often found decalcification of the teeth around the precious metals. Before the war, when he was able to use platinum bands—which he could not get nowadays—he did have decalcification under the bands even when the cement was in good condition and the band remained cemented in place and was not removed until the end of the treatment. Sometimes when he took the band off he found decalcification under it, which was doubtless due to the presence of platinum in the band. He had not found decalcification under the gold he used for his bands, because he always used 22 carat gold; he found that answered the purpose just as well as anything else. He certainly thought that any metal which contained a high percentage of platinum might be dangerous to the teeth. In most cases he had not had any marked decalcification.

Mr. Marsh had been kind enough to express interest in the case he showed at the end of his paper and had asked about skiagrams being taken from an experimental standpoint. He did not have anything like that done. The patient was not wealthy and had to come up from the country about seventy miles each time, and as he himself did not possess an x-ray machine he did not like to ask them to have x-ray photographs taken simply for experimental purposes.

The next speaker asked whether he had had extrusion with the appliance for mesioversion with the band on the lateral. He had not found that to be the case; on the contrary, as the spring was attached to the arch, which was considerably nearer the gingival portion of the tooth, it naturally tended to bring that tooth up rather than down—to intrude rather than extrude it.

Mr. Pitts seemed afraid that the cementum might be exposed when the extrusion movement was carried on. Personally, it had been his experience that the gum line always followed the movement of the tooth. The gum always descended with the tooth and he had not so far seen any exposure of the cementum. On the contrary, he had sometimes to cut away the gum because it had come down too far. In such a case there would be a small exposure of the cementum, but there were apparently no ill-effects from that.

With regard to a combination of expansion going on with the use of these springs, as he mentioned at the end of his paper, one could very well do both things together. The springs only came into play, however, on the anterior teeth—usually just the incisors and sometimes the canines—and expansion usually went on with the other teeth—usually the premolars and molars—so that there was no reason why one could not carry on both things at the same time, and that was what he usually did.

Mr. Chapman's appliance for distogression was very ingenious. He imagined it might be applicable in some cases, but usually he found it more convenient and less risky to use a band than to try to press on one edge of the tooth simply with a spring.

He had only used a high labial arch once or twice and it had not given him the results he had expected. As Mr. Chapman said, it had to be used with the lingual arch, and his paper was concerned with the low labial arch and not with the high labial arch. Springs attached to the high labial arch could probably accomplish most of the things that could be done with the springs referred to in his paper, although unfortunately he had not been as successful with them as he would like to have been. He supposed his patients were not particularly well chosen; there was a good deal in the proper choice of patients.

As to attaching springs to the arch rather than to the band, he quite agreed with the President that it was better to avoid attachments on the bands if possible, but in some cases it was absolutely necessary to make such attachments. In certain parallel movements along the line of the arch, for instance, it could not be done away with.

TWO CASES OF EXCESSIVE OVERBITE TREATED WITH LACE-WIRE INCLINED PLANE*

By H. E. Marsh, M.C., L.D.S., Berhill, Sussex, England

I BRING to your notice two cases of excessive overbite that have been treated with the lace-wire inclined plane. I saw an account by Dr. J. Lowe Young, in the International Journal of Orthodontia, describing this method, and felt that it might be valuable in those cases where patients cannot be induced to wear a vulcanite plate with inclined plane. Both of these children, the first a boy, the second a girl, simply would not wear plates for more than a few days, either when at home or when at school. This appliance cannot be taken out by the patient, but can be removed, cleaned and replaced by the dentist very easily and quickly. Both cases come under Angle classification as Class II, Division 2, and in both cases the overbite was such that the mandibular incisors were impinging on the mucous membrane behind the maxillary incisors.

Fig. 1 shows Case 1 from the front—no part of the mandibular incisors is visible.

Fig. 2 shows the right side in occlusion. The postnormality of the mandible is evident on looking at the first molars.

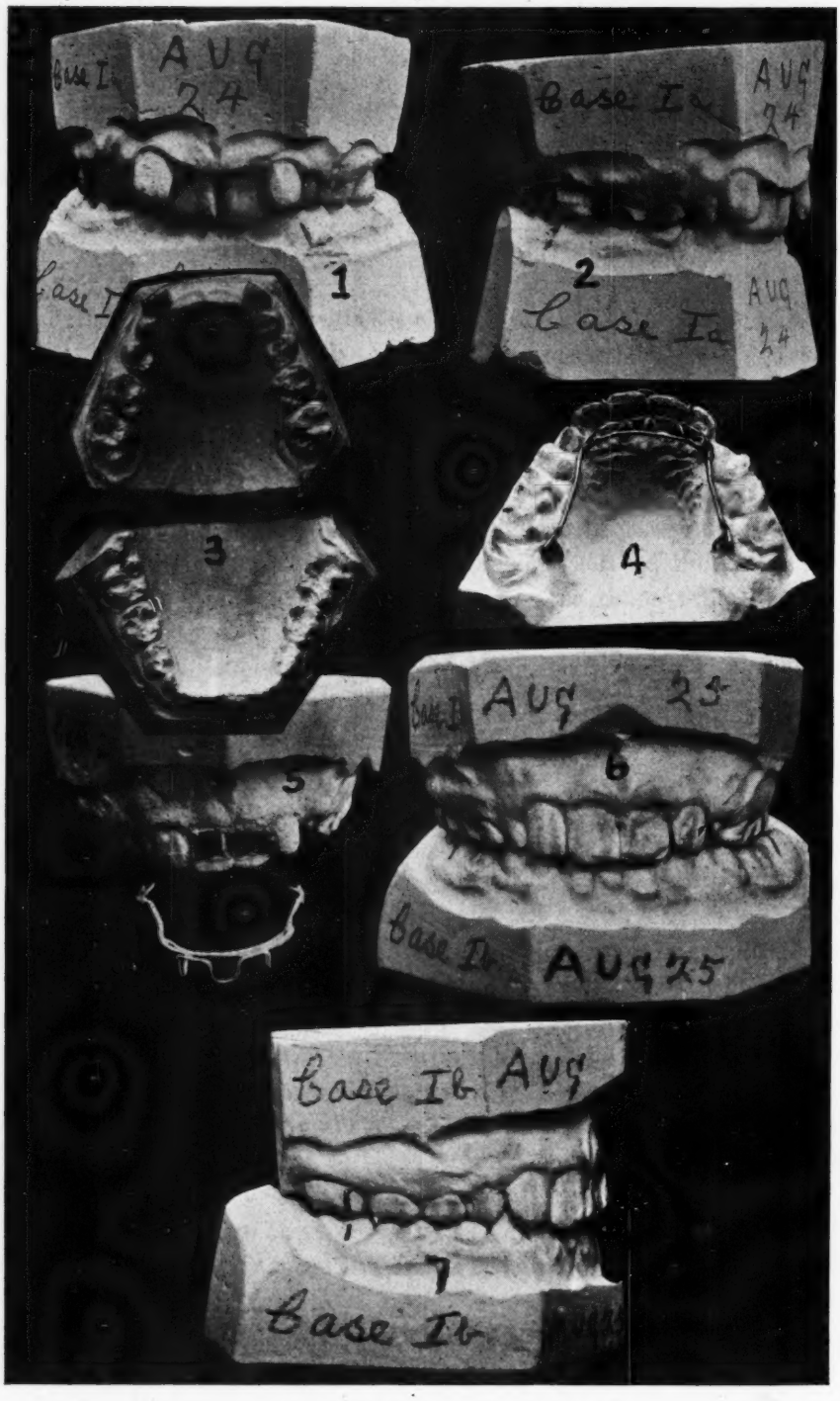
Fig. 3 shows the upper and lower models separately.

Fig. 4 shows the upper model with the lace-wire appliance in position.

I must mention that before commencing the correction of the overbite the maxillary central incisors were moved forward into alignment by means of a labial arch and ligatures, the labial arch being held in the same molar anchor bands as were used for the lingual lace-wire. The latter is constructed on the lingual wire as follows (I here quote J. Lowe Young): "Bands are fitted to the maxillary central incisors, and to these are soldered cleats well toward the labial distal surface of the band parallel to the long axis of the tooth. Heavy cleats are also soldered on the lingual side of the bands transverse to the long axis of the teeth and close to the gingival margins of the bands.

"The first molars are banded, and half-round tubes soldered on the lingual surfaces of the bands parallel to the long axis of the tooth. With the four bands in place an impression is taken, the bands removed and a cast made in artificial stone. A removable lingual wire is then constructed so that it rests on the transverse cleats on the bands on the centrals. Call this the main wire. At a point near the distal margin of one of the canines, attach to the main wire with solder another wire and carry it across to join the main wire again opposite the same place on the other side. In the space between these two wires is fitted a wire bent to and fro, so that the angles of the bends reach the wires on either side and are soldered to them, creating an open

*Transactions of the British Society for the Study of Orthodontics.



inclined plane. The wire thus used is all 0.036 in diameter. Close to the gingival end of the labial cleat on each central band is cut a notch. The end of a wire of 0.026 gauge is soldered to the front portion of the lingual wire at a point opposite the embrasure between the lateral and central incisors on one side. This is shaped so that it passes down the embrasure between these teeth, is bent labially and then arranged to pass up the labial embrasure op-

posite the notch cut in the labial cleat. It is then bent so as to pass across the labial surface of both central bands. A loop is bent in this wire which may present either incisally or gingivally as desired. This loop should be midway between the labial cleats. The wire is then bent so that it assumes a similar position between the central and lateral on the opposite side, and is

again soldered to the lingual wire where it encounters it. If the loop in this labial wire is omitted great difficulty will be experienced in removing and replacing the appliance. It is important that this wire be bent so that it securely seats itself in the notches of the labial cleats. The object of this wire is to stabilise the front portion of the lingual wire carrying the bite plane and also to prevent the centrals moving labially. Then the bands are cemented on the teeth and the appliance adjusted.

"It will be found impossible for the patient to get the molar and premolar teeth into contact. In both cases it succeeded in moving the mandibular into something like normal occlusion and in considerably correcting the overbite."

Fig. 5 shows the incisor bands on the model with the vertical cleats and notches. Also the lace-wire removed, showing the anterior stabilising wire and its loop.

Fig. 6 shows the front view of the models in occlusion without appliances, after a year's treatment.

Fig. 7 shows the right side similarly.

Fig. 8 shows the models separately.

Case 2 is a similar one.

Fig. 9 the front view.

Fig. 10 the right side.

Fig. 11 the models separately before treatment.

Fig. 12 the front view after treatment.

Fig. 13 the right side, and

Fig. 14 the models separately.

I should add that in both these cases some expansion was carried out—in the mandibular arch by means of a lingual arch with two lateral and an anterior loop; in the maxillary arch by means of an auxiliary spring attached on either side to the main wire of the lace-wire appliance itself.

DISCUSSION

The President said Mr. Marsh had shown two cases of unusual interest in which he had obtained exceptionally good results. In the first case he had opened the bite to the extent of more than half the length of the crowns of the incisors, and that must be considered very satisfactory under the difficult conditions.

Mr. A. L. Packham said it seemed to him that in treating cases of the kind, in bringing the mandible forward, it was necessary to expand the maxillary arch. He should like to ask Mr. Marsh how that had been done in the two cases mentioned, whether it had been done by means of apparatus, or whether it had occurred naturally in the course of treatment. He should also like to ask how much of the apparent opening of the bite had been done by a reduction in the height of the mandibular incisors as against the overeruption of the back teeth.

Mr. Marsh said he was sorry he had forgotten to say anything about expanding the arch. There was a lingual arch in the mandible in each case. Both arches needed liberal expansion. In the maxilla in each case he used auxiliary springs on the lingual appliances, attaching them to the lace-wire appliances, and there was plenty of room to do so. They should be put on in front of the vertical rods that went into the molar bands and bent backwards and for-

wards when they would carry out the expansion of the first premolars or first temporary molars, and the temporary canines if present.

Mr. George Northcroft said that in the case shown the lower incisors seemed to have been depressed only. He thought in all cases of raising the bite it was well to emphasize the point brought out so well by Mr. Dolamore when he said that such cases should be undertaken at the physiologic age of eruption of either the first or the second molars; that was to say, about the age of six or twelve years, or at the time when the molars were beginning to erupt. A physiologic growth of bone then took place, a normal growth, and consequently a more permanent result was likely to be obtained. Since he had been operating on those lines he had had what seemed to him more permanent success in cases where the bite was raised.

Mr. Schelling said that if he had judged rightly from the models it seemed clear that the maxillary premolars had come down nearly to the length of the canines.

Mr. Robert Lindsay asked whether Mr. Northcroft would agree that what took place with regard to the six and twelve-year-old molars would be equally true of the development of the premolars. He thought that was the point Mr. Schelling wished to know. It seemed to him that if the developing bone—and it was a theory which his wife and himself had taken notice of in their paper—if the deposit of bone on the alveolus helped to carry up the six-year-old molar and the twelve-year-old molar, the same rule must apply to the premolar, and the bite would be opened in that way.

Mr. George Northcroft said that orthodontists dealt with the case of molars chiefly and simply because a little growth gained at the back of the jaw meant a great deal of opening of the bite in front, whereas the raising of the first premolar would only open the jaw a very little. What they were after was to open the bite, and the best effect was obtained from the back of the mouth.

Mr. Lindsay said he quite agreed, and it emphasized that such things were most effectually done if it were possible to get locking of that description. He thought everyone agreed that the best way to get the locking was at the posterior end of the second molar.

The President said that one thing he had noticed about the inclined plane was that it was very nearly horizontal rather than vertical. He had been in the habit of making his planes much more vertical, and he thought with less success, and he hoped to adopt Mr. Marsh's plan. He had used lace-wires generally with a labial arch instead of a labial section on a lingual arch, because he had found them more easy to manipulate. The additional piece across the front he had found a rather difficult thing to deal with. He had used the lace-wires without bands on the incisors. They seemed to be effective although, of course, more easily damaged.

CASUAL COMMUNICATIONS

Mr. William Ovey showed two cases which he had found in inspecting L.C.C. school children, and although not strictly orthodontic cases, were of unusual interest. The first exhibited a general atrophic condition of the enamel in the second dentition, the right maxillary incisor being affected to such an extent that a vertical line of nearly 2 mm. runs down the labial surface of the tooth with apparently no enamel covering whatever. The patient is the youngest of eight children, and attends a school for physically defective children, chiefly on account of varicose veins and inability to maintain his equilibrium when playing with other children. The supplemental tooth behind the maxillary incisors occurs in two other members of the family.

The second case was that of a boy having a large congenital tumor (lipoma or lymphangeoma) of the left cheek, having the appearance of an alveolar abscess, and which is the cause of considerable embarrassment to the child. The mother states that she had several teeth extracted during the fourth month of pregnancy, and was upset by the loss of her own mother a few weeks before his birth. A cyst was removed at the upper border of the tumor about two years ago, but no attempt has been made to operate on the tumor itself.

The President said the cases were two very admirable ones and of very great interest.

Mr. Northcroft asked if the lipoma was noticed to have any effect on the position of the teeth in the mandible. Unfortunately he could not closely examine the teeth inside the mouth.

The President said he happened to see inside the boy's mouth that the mandibular teeth were not unusual except that there was a badly carious second molar.

Mr. A. T. Pitts said the lipoma case did not seem to cause any deformity of the jaw at all. Two cases were recently brought before the Society in which the presence of tumors had caused a certain deformity. He supposed the explanation was that the lipoma was so extremely soft and elastic that it had not exerted any effect on the jaw.

The President exhibited two instruments recently sent him from America, one being the Clevedent Scaler, No. 24, which was very useful for unlocking a lingual arch. He also showed a pair of pliers for closing the soft locking wires in difficult cases.

TWO CASES OF HEREDITARY SUPERNUMERARIES IN SAME FAMILY (CASE REPORT)*

By Raymond L. Webster, Providence, R. I.

THIS case is reported as an hereditary condition, existing in only one of a pair of twins and again in the next younger child.

The mother gave history of a supernumerary tooth in her own mouth, palatal to upper central incisors, found by the late Dr. John Nutting Farrar of New York, thirty years ago. Mention is made of same in his book (*Irregularities of the Teeth and Their Correction*, i, p. 730, Fig. 689-A).

Fig. 1.

Fig. 2-*A*.

Fig. 2-*B*.

Radiograms of her three children preparatory to orthodontic treatment, showed a small supernumerary tooth palatal to right superior central incisor in one of twin girls, eleven years of age (Fig. 1). None showed in other twin, but in a younger brother, age seven, a perfectly formed supernumerary lateral incisor was found, palatal to left superior central (Figs. 2-*A* and 2-*B*). In his case, neither central incisors had erupted, and upon their eruption at age seven and one-half, assumed position lingual to lowers. At age eight and one-half the supernumerary tooth was removed in the boy's case and a cyst was found attached. To date the girl has not been operated upon.

*Given before the First International Orthodontic Congress, August 16-20, 1926.

ORTHODONTIA AND ITS USES IN THE PRELIMINARY TREATMENT OF EXTREME CASES OF HARELIP AND CLEFT PALATE*

By Dr. Joseph J. Millard, New York City

CASE 1.—The first case to be presented is rather an interesting one. It offers a very good opportunity to demonstrate the importance and necessity of orthodontic treatment in preoperative proceedings. Another point it

Fig. 1.

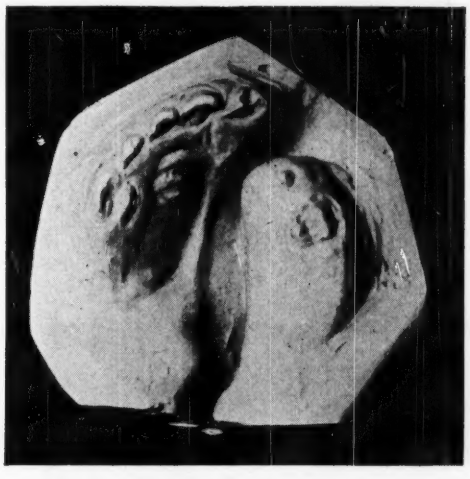


Fig. 2.

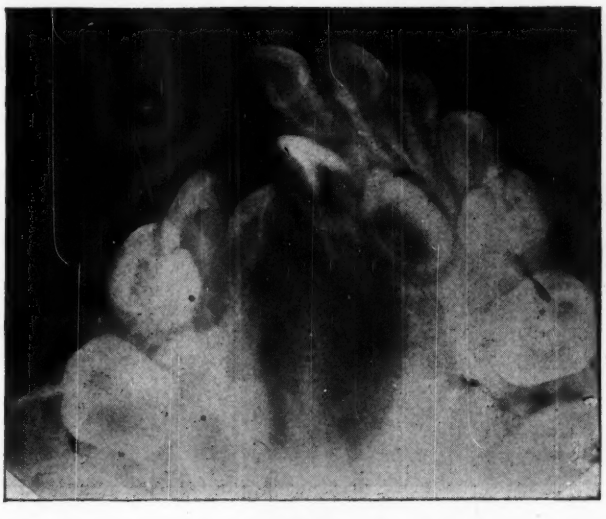


Fig. 3.

brings out is that a lip operation may be successfully performed over a malformed maxilla—successful in so far as drawing lip tissue segments together—but without orthodontia treatment to restore normal contour to the maxilla and in this way provide a balanced basis for the soft tissue, normal facial contours cannot be obtained and the very object of the lip repair is defeated.

*Case Report given before the First International Orthodontic Congress, New York City, August 16-20, 1926.

Fig. 4.

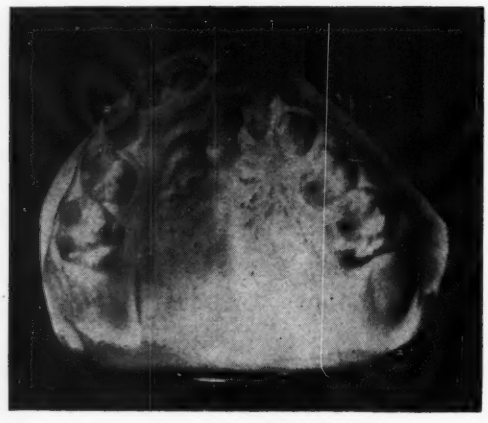


Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8. Fig. 9. Fig. 10.

The patient presented in Case 1 was brought for treatment at the age of eighteen months and gave a history of having had one previous unsuccessful operation. Fig. 1 shows the patient at time of reporting. Fig. 2 is a model of the case as it presented.

The reader will note the facial depression as caused by the distorted position of the malposed fragment of maxilla. Fig. 3 is a radiograph of case.

In preoperative treatment of this case it was decided to apply an apparatus that would swing the anterior portion of the malposed maxilla buccally; that is, to get a pivotal action with the posterior portion remaining in approximate position and anterior portion moving buccally.

The extent of this proceeding was governed, as the reader can readily

Fig. 11.

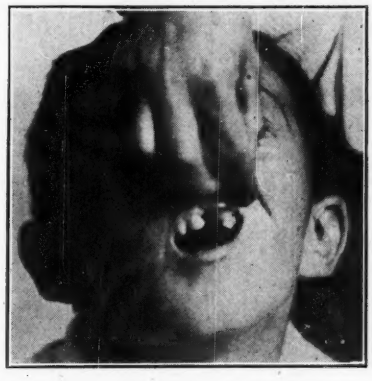


Fig. 12.

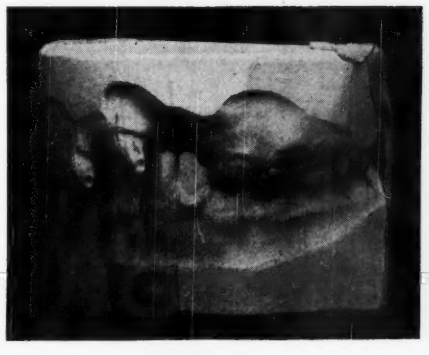


Fig. 13.

Fig. 14.

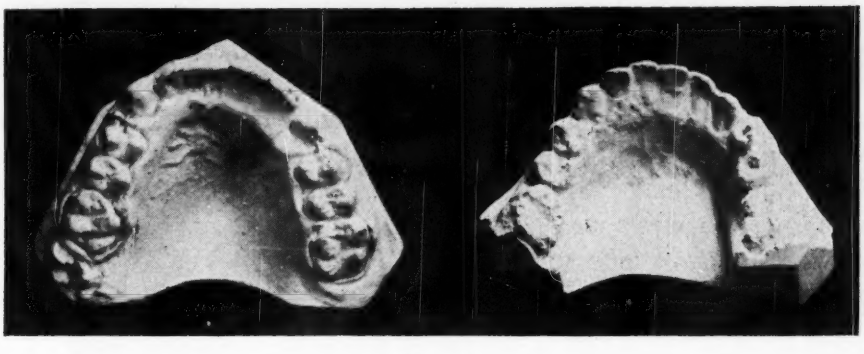


Fig. 15.

understand, by the width of the cleft in the palate, the object of the treatment being to obtain, as close as possible, normal contour of the arch without unduly widening the existing palatal cleft.

Fig. 4 shows the patient shortly after the palatal repair was completed.

Fig. 5 is a model of the arch at that time. With the maxilla as presented

in Fig. 5, the lip repair was taken up, with results of the proceedings presented in Figs. 6 and 7.

Case 2.—The history of this case proves again the usefulness of orthodontic treatment in some cases of palate repair.

The patient presented at age of two and one-half years with a history of two unsuccessful operations.

Upon examination a cleft of unusual width was disclosed, also the absence of premaxilla, as presented in Fig. 8.

The first step in the preparatory treatment was the placing of an orthodontic apparatus. It might be well to describe at this point the details of the apparatus. Bands were placed on the second temporary molars and cuspids. Buccal tubes were placed on molar bands and the cuspid and molar bands were united by means of a No. 18 wire placed lingually. This made it possible to get a bodily movement of the maxillary fragment with little or no tooth displacement. An arch wire was adjusted with pressure toward the medium line.

Fig. 16.

In this manner the cleft was reduced (Fig. 9) to such an extent that the repair operation was readily accomplished, as presented in Fig. 10.

Case 3.—The effect of a distorted maxilla upon the contours of the face is very apparent in this case. Fig. 11 shows the existing condition at the time the patient reported. Examination of the mouth disclosed two missing incisors, the germs of which were destroyed during the course of some previous operation. Figs. 12 and 13 show very clearly the distorted condition of anterior portion of upper arch.

An apparatus was adjusted with results shown in Figs. 14 and 15. The missing centrals were replaced by means of small rubber plate, which also acted as a retaining device.

Fig. 16 shows patient at the time the orthodontia treatment was finished, at this stage the patient was ready for the plastic repair, the object of which was to improve the contour of nose and to remove the excessive scar tissue on the lip.

UNDERDEVELOPED MAXILLA AND OVERDEVELOPED MANDIBLE (CASE REPORT)*

By Dr. William A. McCarter, Topeka, Kansas

Young lady, age seventeen years.

Treatment.—Almost continuous for five years. Appliance used: Lingual arch with finger springs and extension lock, also expansion ribbon arch.

Fig. 1.

Fig. 2.

Fig. 3.

*Given before the First International Orthodontic Congress, New York City, August 16-20, 1926.

Fig. 1 shows lateral views of case before and after treatment.

Fig. 2 shows front views of case before and after treatment.

Fig. 3 shows occlusal view of both upper and lower arches before treatment.

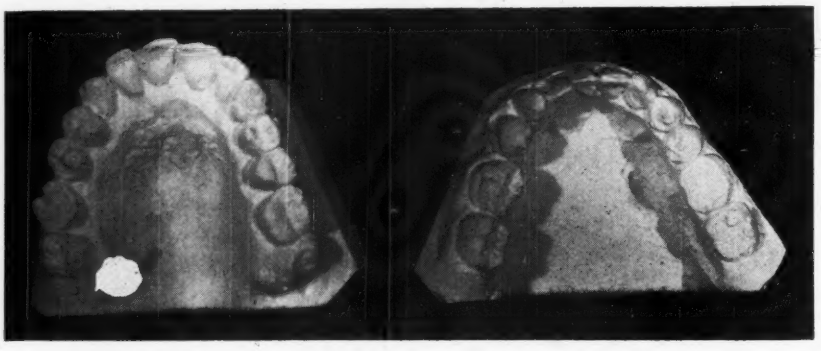


Fig. 4.

Fig. 5.

Fig. 4 shows occlusal view of both upper and lower arches after treatment.

The result of the treatment of this case is shown in the mirror picture shown in Fig. 5.

ORIGINAL PHOTOGRAPHIC STUDIES OF ORTHODONTIC CASES*

By Dr. Henry C. Ferris, New York City, N. Y.

FOR years we have looked at photographs of our patients and have failed to recognize in them any particular diagnostic factors of the arrested development we are treating, other than to view a distorted face. We have

Fig. 1.

Fig. 2.

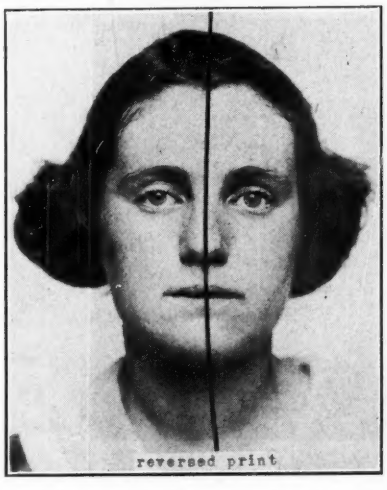


Fig. 3.

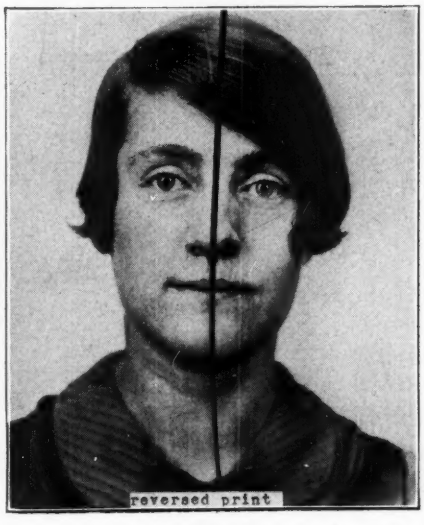


Fig 4.

been more interested in the plaster model of our problem, and have overlooked the valuable information which photographs can give us in completing our diagnosis and directing appliance design.

This was my personal experience, until I commenced to dissect the full

*Clinic given before the First International Orthodontic Congress, New York City, August 16-20, 1926.

face view of my records, and noted the deformity of the medial line of the face and the discrepancy in the measurement between the corner of the mouth and the corner of the eye, when bilaterally compared.

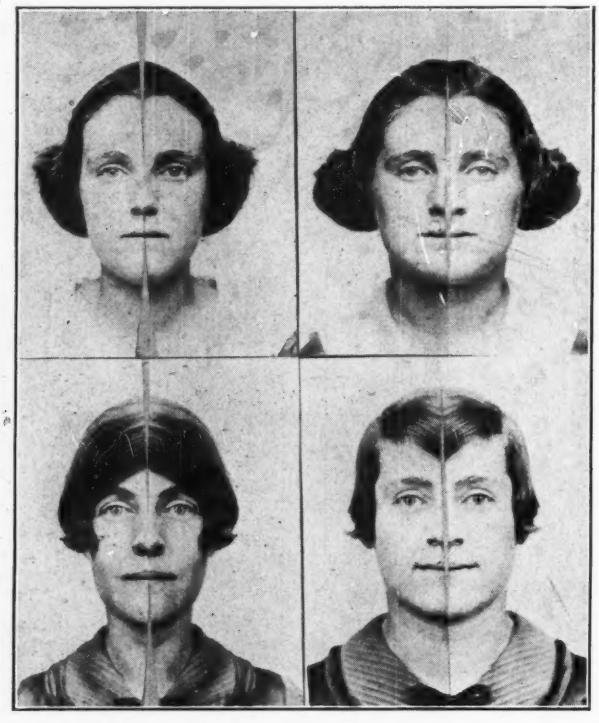


Fig. 5.

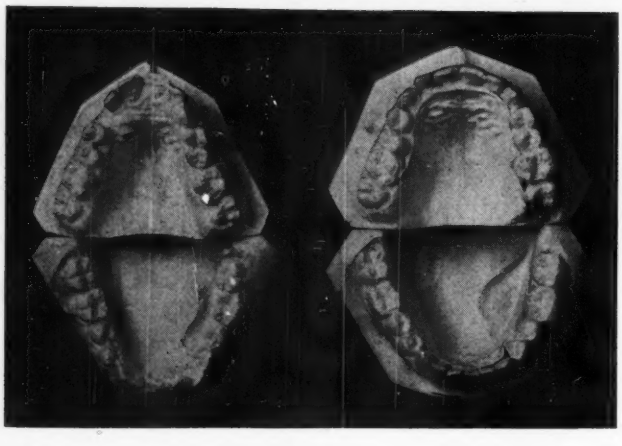


Fig. 6.

The conformation of the maximum horizontal plane of the cranium when studied with a conformateur also supplies contributory evidence which parallels the deformity of the bones of the face and maldevelopment of the dental arches.

Anthropologists have stated that the cephalic index of the skull in normality does not necessarily parallel the dental index; i.e., a long head may be accompanied by a round arch of teeth, and a flat head may possess a sphe-

roidal or parabolic arch; or in fact, any arch may appear with any cephalic index, and still be normal. This is a recent statement by Prof. Alec Hrdlicka of Smithsonian Institute, Washington, D. C., and is a contradiction of earlier beliefs.

I will state, however, that the unilateral or bilateral deformity of the bones of the head and face, in a large percentage of cases, parallels the deformity of the maxillary arch of teeth, and this you may observe to your own satisfaction by a study of these factors in your cases. Whether this deformity is a variation or modification of the cranium, has yet to be proved. I will present some evidence in favor of the theory of modification.

The patient, shown in Figs. 1, 2, 3, 4, 5, 6, and 7, presented herself for treatment in 1920 with an impacted right maxillary canine. She was then

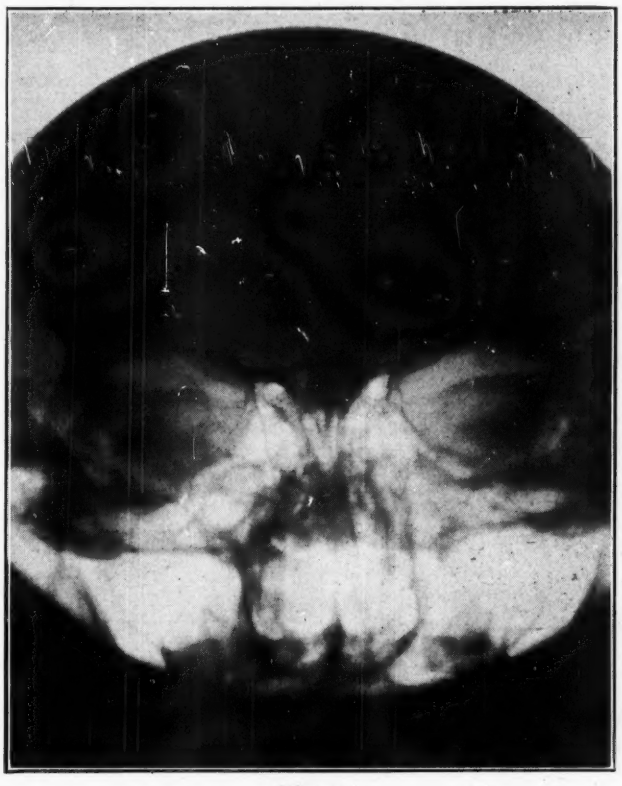


Fig. 7.

seventeen years of age. Fig. 3 shows the patient at twenty-three years of age. By using a French curve, the medial line of the face was determined.

It would appear logical that where normal or excessive muscle function is practiced, the highest potential of the growth of the bones to which these muscles are attached will be attained; and the reverse is no exception to the rule.

Study your cases from this angle, and when you discover a unilateral deformity in the face, you can prove your findings with a unilateral development of the skull with a conformateur record, and with an extraoral occipital radiogram of the bones of the face and nose. The medial line of the interior osseous structure of the nose parallels the external line of the face,—the convexity of the curve being toward the normal side.

The earlier this defect is recognized in the structural development, the more valuable is orthodontic treatment as unilateral habits of mastication once established, become chronic, and the structural weakness is modified by abnormal occlusion of the teeth.

A method of photography, as presented by your essayist before the Alumni Association of the Angle School of Orthodontia a number of years ago, has proved to be a very valuable aid in making this study practical.

The patient is placed about four feet from the camera, the center of the lens is in a horizontal plane with the naison and the tragus; the shoulders are placed at right angles to this line. The camera is focused upon the mouth with a 19½ inch lens.

Fig. 8.

Fig. 9.

The light should be directed at an angle of 30° downward and the face bilaterally illuminated, which can be accomplished by reflecting screens on either side of the patient. The shadows which are cast emphasize the lines of the face, and should be bilaterally equal under the chin.

This focal distance should give a head 3¼ inches on the ground glass, above and below which two horizontal lines can be drawn to assist the posing of the patient.

The picture at completion gives a head about one-quarter of the normal size, and presents an error in refraction not exceeding 10 per cent, as stated by engineers of the Eastman Kodak Co. This error of refraction cannot be detected by the eye. The general effect permits a more accurate ocular comparison than heads of one-half or full size, and the one-quarter size may be enlarged without loss of the comparison.

If a second picture is made in "laughing" pose, it presents another diagnostic point in so much as it registers the bilateral or unilateral nerve tone of the muscles in action. To be sure, such a photograph is but a high point

of a moving picture, and can only be accepted with such recognition; but it is very interesting to note that when the osseous structures, bones and teeth, are normal, the nerves and muscles will increase in their tone and function. By this method you are able to prove the results of your treatment.

In order to emphasize the amount of correction of the medial line of the

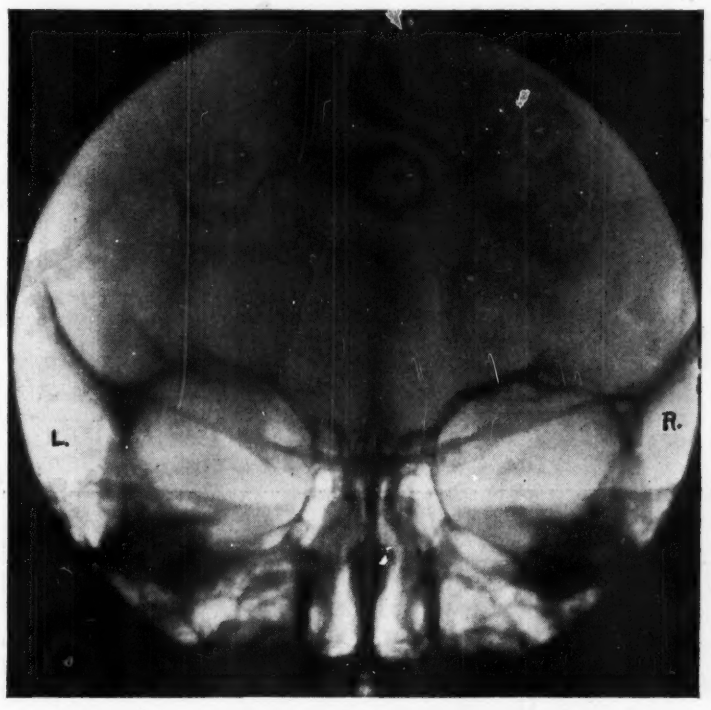


Fig. 10.

Fig. 11.

face through orthodontic treatment, I have made sections of the positive print, bisecting it on the medial line (by using a French curve) (Fig. 8), then making a reversed print from this negative; and by placing the positive and negative prints of each side of the face together at the contact points, produced a photograph of two faces composed of the component parts of each right and left side (Figs. 9, 10, 11, 12, 13).

The result is spectacular, which exaggerates the deformity that exists before and after treatment, but actually defines any correction in the curve by comparison. The width of both faces thus made is incorrect, but proves that the corrected occlusion in older subjects may not entirely result in overcoming the arrested development of the maxillary bones of the defective side.

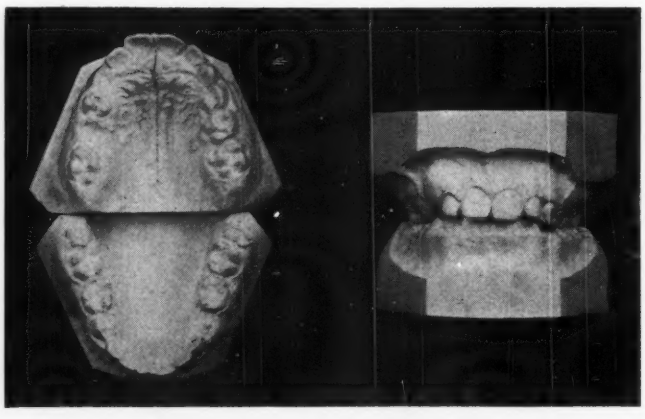


Fig. 12.

Fig. 13.

The final result, however, more nearly approaches the normal balance and the medial line is straightened in subsequent chronologic growth.

I am convinced that in younger subjects congenitally normal, a perfect balance can be attained; and the radiograph taken before and after, may prove this contention. This study proves to be interesting, and gives promise of further development in diagnosis and prognosis of our operation.

SERIES OF PHOTOGRAPHS OF DISSECTED SKULLS SHOWING DEVELOPMENT AND ERUPTION OF TEETH, AND MODELS OF NATURAL TEETH*

By Dr. W. G. Hughes, Walla Walla, Wash.

THIS clinic is intended to show by photographs of skulls, some of them dissected, and by plaster models, something of Nature's handiwork in the development of the teeth and supporting tissues.

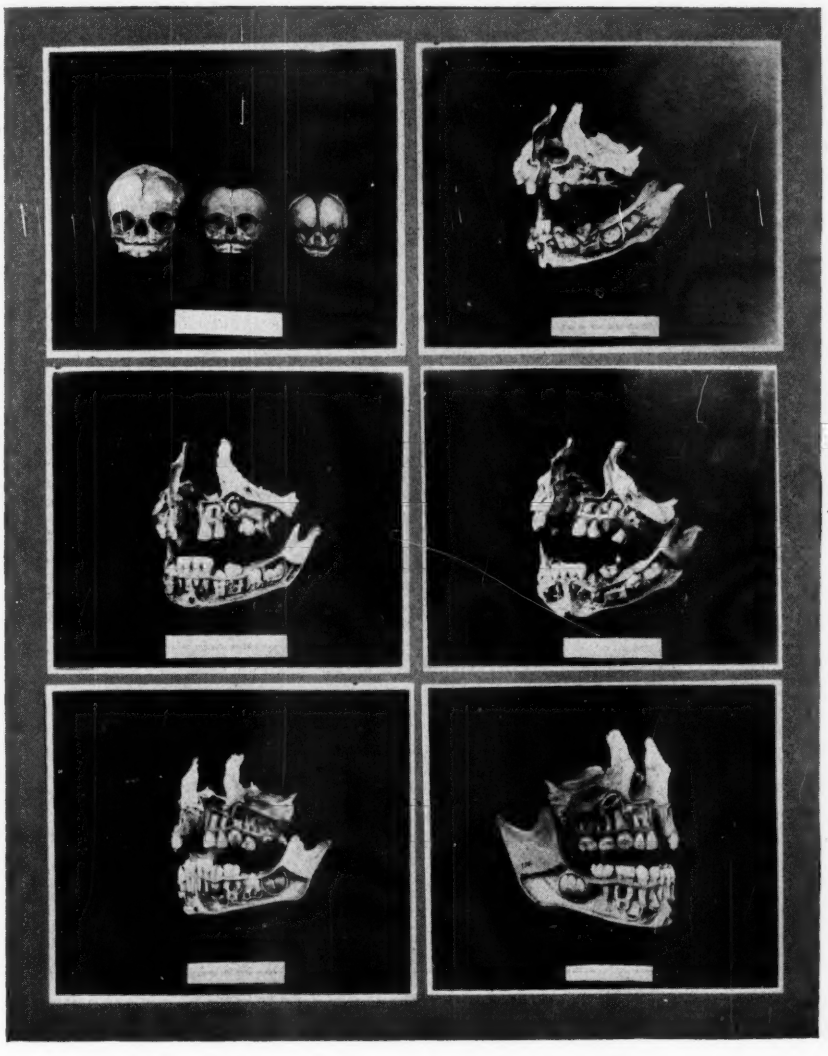


Fig. 1.—*A.* Seventh, eighth, and ninth month after conception. *B.* Ninth to tenth month. *C.* About the thirteenth or fourteenth month. *D.* About the fifteenth month. *E.* About the seventeenth month. *F.* About fourth year.

The skull pictures were selected from a number of photographs taken by Dr. H. C. Puckett, a child specialist of Seattle, who in order to secure them spent a great deal of time in visiting museums and in preparing specimens.

*Clinic given before the First International Orthodontic Congress, New York City, August 16-20, 1926.

The photographs show different stages of development of the teeth and their supporting osseous tissue, from seven months after conception to old age. Also a full set of deciduous teeth mounted to show the root development about the fourth year.

The plaster models are of cases from the fifth year to the twentieth; also a set showing how nature accommodates itself, in one case at least, to the loss of teeth and a distal occlusion.

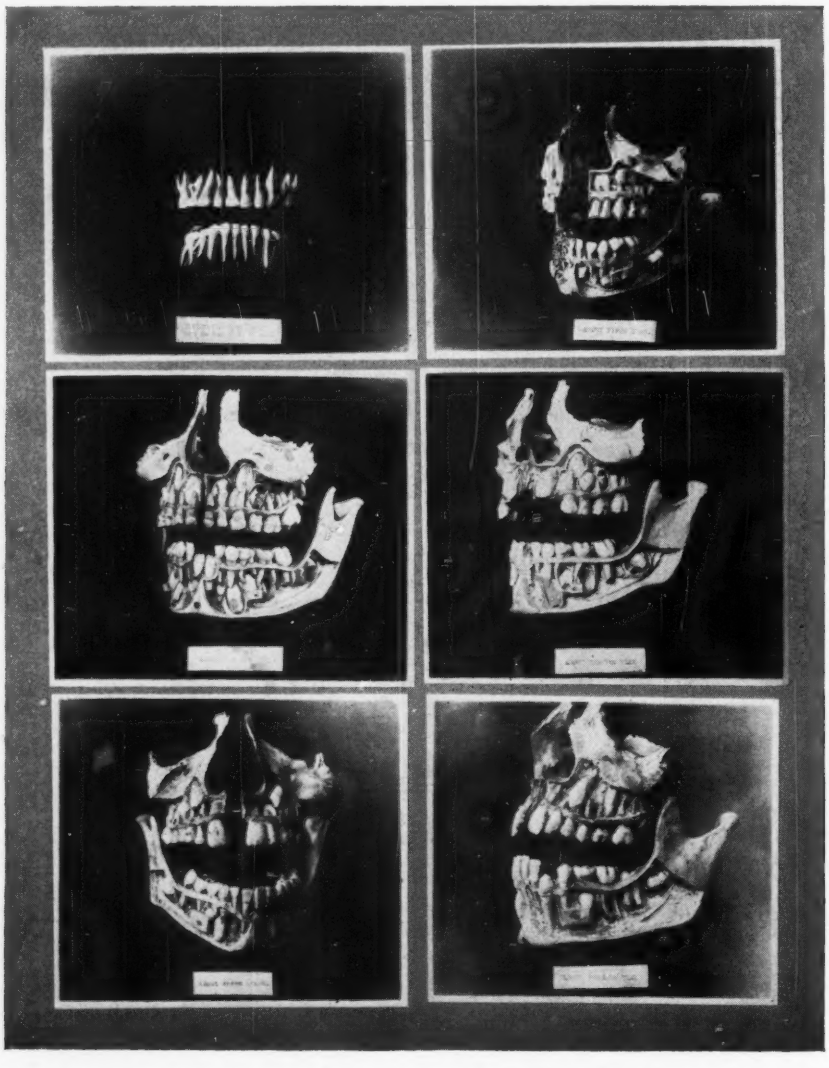


Fig. 2.—*A*. Deciduous teeth about third to fourth years of age. *B*. About fifth year. *C*. About the sixth year. *D*. About the seventh year. *E*. About seven years. *F*. About the tenth year.

Model D (Fig. 4) is that of a five-year-old child showing regularity of the teeth and the space being developed in the anterior region to make room for the permanent incisors, also showing space for the eruption of the six-year-old molars.

Model F (Fig. 5) shows the teeth of a child of seven with the mandibular six-year-old molars and right mandibular central incisor erupted with ample

room for the left mandibular incisor to erupt; also note the well-developed arches.

Model C (Fig. 6) shows the development at fourteen years of age. Occlusion and arch development excellent. Note some open contact and that the teeth do not seem to have fully erupted, also very heavy supporting tissues.

Model G (Fig. 7) has a slight rotation of the right maxillary lateral and canine but the arches are well-developed and the occlusion is good at the age of fifteen.

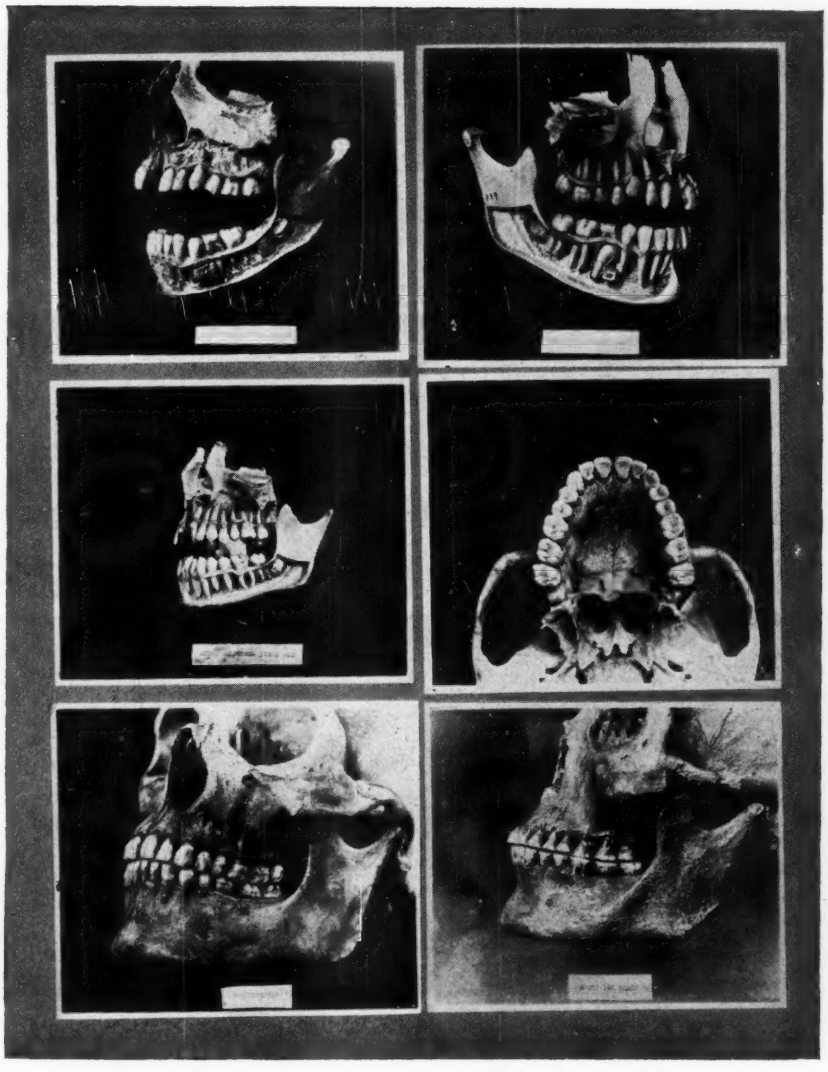


Fig. 3.—*A*. About eleven years old. *B*. About the twelfth year. *C*. About thirteen years old. *E*. Complete set. *F*. About one hundred years.

Model E (Fig. 8), an almost perfect set of teeth, shows light supporting tissue, the roots of the teeth being plainly evident in the osseous tissue, the lingual cusps of the maxillary premolars occluding in the distal fossa of mandibular premolars. This patient was twenty years of age.

Model B (Fig. 9) shows rather a square type of occlusion, fine teeth and almost perfect occlusion; mandibular third molars are erupting. The

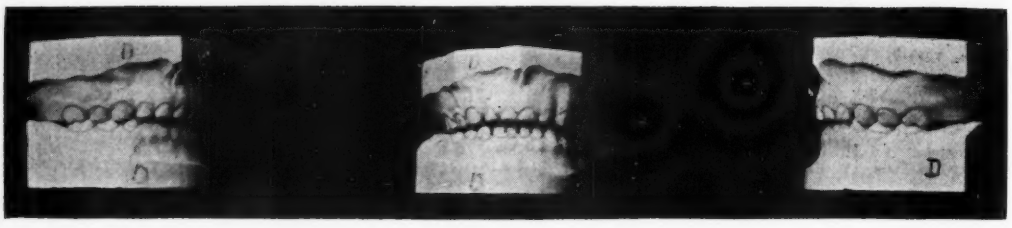


Fig. 4.

Fig. 5.

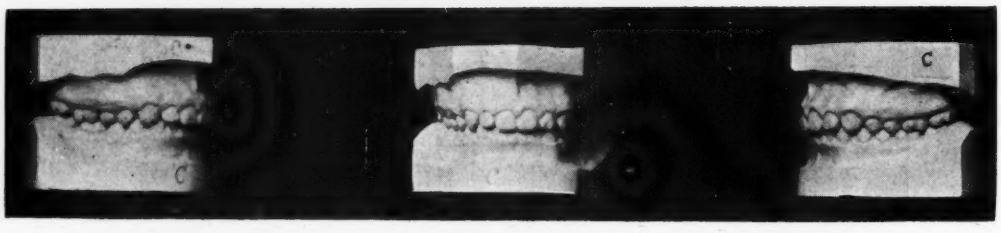


Fig. 6.

Fig. 7.

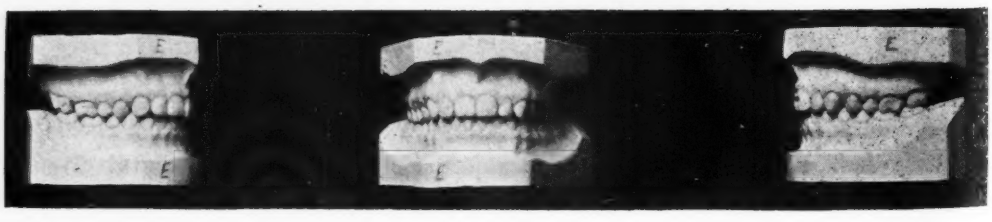


Fig. 8

central photograph shows the occlusion of the lingual cusps, of the maxillary premolars not occluding in the distal fossa of the mandibular premolars.

Model A (Fig. 10), patient aged forty-five, showing erosion of the occlusal surfaces of all the teeth, more on the right side than on the left. Maxillary left canine and mandibular left first premolar missing, no history of extraction; although a distoclusion case the excursion of the mandible has been so extensive that the incisor teeth have been worn down equally with the molars and premolars.

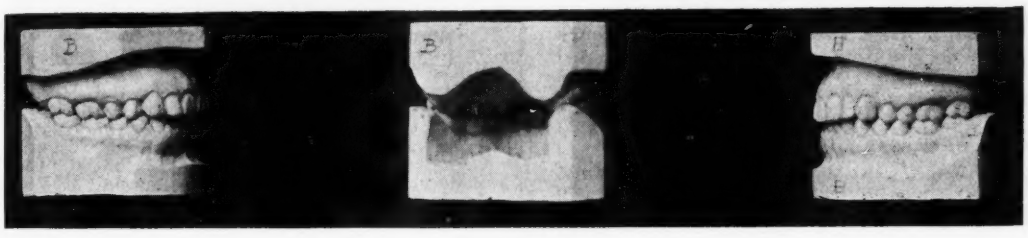


Fig. 9.

Fig. 10.

May I suggest that it would be a great service to dentists and their patients if the orthodontist would supply models of normal teeth to their dental friends? The average dentist as a rule looks at the teeth of his patients with a mouth mirror, seeking cavities, and seldom pays much attention to occlusion. As a rule parents and friends seem to realize the need of orthodontic treatment more often than the family dentist.

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EDITORIALS

"Class II"

DURING the past number of years it has been our privilege to read a great many articles on orthodontics, listen to a number of papers and see several clinics. During that time we have been impressed with the large number of conditions grouped under the heading of "Class II." Primarily, all Class II cases should have certain characteristics but we find a lack of differentiation regarding factors, which has led to confusion. There is no term in orthodontic literature which has covered such a large number of variations of conditions as "Class II." This has been due to the fact that some men have failed to realize that many of us mean a Class II malocclusion: while others have realized that many conditions differ but still call them Class II. Undoubtedly, the term "Class II" has been taken from Angle's Classification which should refer to those types of malocclusion characterized by a posterior posi-

tion of the mandibular arch in relation to the maxillary arch. You will notice we have used the word "arch" instead of "first molars" because a large amount of confusion has been due to men having based the posterior relation of the mandibular arch upon the position of the molars.

It was early recognized by many that a classification of so-called "Class II" condition based upon anteroposterior relation of the molars would be confusing. In other words, it has been shown that it is possible to have an abnormal anteroposterior locking of the first molars as related to each other without having a posterior position of the mandibular arch. Such a condition can be produced by early extraction of the maxillary deciduous molars allowing the maxillary first permanent molars to drift forward.

As a result of the tendency of maxillary first molars to drift forward due to certain conditions, Dr. Case early recognized the possibility of maxillary molars and premolars drifting forward; and as a result of this, he divided conditions which others had placed under Class II, into several groups. In one group he placed those conditions in which the maxillary arch occupied a normal anteroposterior position to the face and cranium, and the mandibular arch occupied a posterior position to the maxillary arch as related to the face and cranium. In this group are found the only true Class II cases or what are better known as posterior occlusion cases. Another group of so-called "Class II" conditions as mentioned by Case were those in which the maxillary arch was described as having an anterior position to the face and cranium with the mandibular arch occupying a normal position to the face and cranium. If such a condition as this actually existed, and some claim that it does, it would not be a Class II case or one of posterior occlusion. As a result of the possibility of the maxillary molars and premolars drifting forward and the mandibular arch occupying a normal relation, we find it quite difficult to select one word or symbol which would describe this condition without confusing it with something else.

If we consider that classification of arch conditions is based upon the anteroposterior of the mandibular arch as occluded to the maxillary arch when related to face and cranium; and that the mandibular arch is the movable arch—figuratively speaking—we find that one can quite satisfactorily employ the terminology as suggested by Lischer in describing those cases where the maxillary teeth have drifted forward and the mandibular teeth have remained normal to the face and cranium. Such a case can be described as one of neutroclusion with an anterior position of the maxillary arch. The term "neutro" is used to signify a normal anteroposterior position of the mandibular arch related to the face and cranium, admitting that the maxillary teeth may occupy any of the malpositions recognizable.

It seems to us, however, that it would be more simple and more definite to describe the conditions which men have called "Class II" where the maxillary arch has drifted forward, by recognizing that you have a complication that can only be explained by the use of proper words and not by the employment of symbols. Instead of calling these conditions "Class II" when they are in no way similar to the other group which has been referred to, we can speak of them as a case in which we have a normal anteroposterior

relation of the mandibular arch, with an anterior position of the maxillary molars and premolars, as related to the face and cranium. The only difficulty that then remains is to find a definite basis for the relation of the arches to the face and cranium. This can only be done by taking into consideration the race and type of the individual and other anatomic factors which may be influenced by development. Dr. Case also referred to another condition as belonging to the so-called Class II group in which the maxillary arch occupied an anterior position and the mandibular arch occupied a posterior position. So far as the posterior position of the mandibular arch was concerned, such a case would take the characteristics of a true Class II case by posterior occlusion; but the anterior position of the maxillary teeth in no way contributes to calling the case "posterior occlusion," or can it in any way be recognized as one of the characteristics of "Class II," but has an entirely different complication. The anterior position of the maxillary molars may be an etiologic factor and must be considered in treatment; but it is impossible to have a classification of malocclusion which can satisfactorily include abnormal condition, etiology and treatment under one symbol. We find the use of "Class II" has been very confusing in that writers have referred to two entirely different conditions and grouped them under the heading of "Class II."

We find that Hellman in his "Studies on the Etiology of Angle's Class II Malocclusal Manifestations," read before the American Society of Orthodontists in Atlantic City, 1921, and published in the March issue of the INTERNATIONAL JOURNAL OF ORTHODONTIA, ORAL SURGERY AND RADIOGRAPHY in 1922, has classified as Class II, conditions which by his own statement he later proved were not true Class II or posterior occlusions. He states that an examination of skulls shows the mandibles of so-called Class II, division 2, were the same as those having normal occlusion but the maxillary arch was different. Therefore, instead of the case described being a typical Class II or posterior occlusion it was only a case in which the maxillary molars and premolars had drifted forward, and therefore should never have been referred to as a "Class II" case.

A similar incorrect usage of the term "Class II" was employed by Dr. Mershon in presenting a case report before the American Society of Orthodontists at the recent meeting in Chicago. The title of the paper referred to two types of Class II, one of which was a typical Class II or posterior occlusion, the other being, according to Dr. Mershon's own diagnosis, one in which the maxillary molars had drifted forward. The case in which the maxillary molars had drifted forward was never a posterior occlusion and should never have been referred to as a Class II condition. If they were both posterior occlusion they should have been treated by bringing the mandibular arch forward, or attempt to do so as was done in the one case. The other so-called Class II case where the maxillary molars had drifted forward was treated by moving the maxillary molars backward to their normal position.

The universal usage of "Class II" in describing those cases where the permanent molars have been locked abnormally has led to endless confusion in both classification and treatment. We are editing at the present time, an

article translated from a foreign language in which the author used "Class II" in a universal way, and which can be readily seen is confusing in attempting to describe the conditions referred to. The basic principle of classifying malocclusions in accordance with the position that the mandibular arch occupies to the maxillary arch in anterior posterior is good. It must be recognized, however, that both the maxillary and mandibular arches must not only be related to each other but they must be considered in their relation to the face and cranium. If one must use "Class II" in describing posterior occlusion, it should be limited to those cases in which the mandibular arch has an abnormal relation to the face and cranium with the maxillary arch occupying a normal position.

FORUM

Report of Round Table Discussion*

Table No. 1.—Topic: What is the present status of the laboratory-made orthodontic appliance? Is it doing any service for the public, or is it, in the aggregate, a failure? After all, the question is "does it benefit the public?"

Chairman—Charles R. Baker, Evanston, Illinois.
Vice-Chairman—R. C. Willett, Peoria, Illinois.

Letters were sent to all the members of this group by the chairman, urging them to thoroughly consider this topic and be prepared to definitely express their opinions. One of the members sent a set of models to a laboratory and had them make appliances and send such instructions as they thought were indicated in the case. Throughout the discussion it was evident that serious thought had been given to the topic and the following report is the result of earnest consideration. The group agreed that the following statement adequately covers the subject.

1. Are appliances made in commercial dental laboratories entirely satisfactory for use by orthodontists?

Answer—NO. Unanimous vote.

2. Are orthodontic appliances made in commercial laboratories to be recommended for use by dentists?

Answer—NO. Unanimous vote.

3. Are appliances for corrective orthodontic treatment, which are removable by the patient, to be recommended for use by the dentist?

Answer—NO. Unanimous vote.

4. If the laboratory-made orthodontic appliances in the hands of general practitioners of dentistry, do not, in the aggregate, benefit the patients, what is the best means to discourage their use?

Answer—Educate the public, particularly through the dental profession, the press and the public schools.

It is respectfully suggested that the American Society of Orthodontists have a Public Education Committee, to handle this and other problems.

Table No. 13.—Topic: What do you think is the best, most practical and most satisfactory method, from the standpoint of the patient alone, of handling cases one hundred miles or more remote from a skilled orthodontist?

Chairman, Dr. Oliver W. White, Detroit, Mich.
Vice-Chairman, Dr. Milton T. Watson, Detroit, Mich.

*Report of Round Table Discussions held at the Twenty-sixth Annual Meeting of the American Society of Orthodontists, May, 1927.

Synopsis of discussion:

First: Type of case and number of visits patient would be able to make to orthodontist over a given period.

Second: Proper selection of appliances best adapted to whatever condition exists. Considerable discussion took place regarding appliances, and opinions were varied, so that no definite data can be given on this phase of the question.

Third: The group were of the opinion that sharing the responsibility of orthodontic treatment with others was very unsatisfactory in the majority of cases.

Conclusion: A satisfactory method cannot be suggested to apply to all cases of this description on account of cases and conditions having such a wide variation.

Table No. 5.—Topic: So-called rapid treatment vs. conservative treatment. What is the trend of opinion?

Chairman, J. A. Gorman.
Vice-Chairman, I. B. Stilson.

We agreed that if rapid treatment meant eight to ten months to complete cases we were not in favor of it.

Nor were we in favor of treating cases without any interruptions or rest periods for four or six years. Yet it was agreed that cases taken at the age of eight or nine years necessitated suspension and more or less treatment for three or four years.

The general opinion was against so-called rapid treatment.

ORTHODONTIC NEWS AND NOTES

The Alumni Society of the Dewey School of Orthodontia will hold a scientific meeting at the Hotel Vanderbilt on August 29, 30, and 31, 1927. These days will be devoted to a scientific program and the remaining days of the week will be taken up with clinic demonstrations and the design and construction of appliances.

The following papers so far have been secured for the program:

A Résumé of Four Years of Study at the Good Samaritan (Endocrine) Clinic with Special Reference to Eight Hundred X-ray Hand Pictures and Their Relation to General Bone Progress.—Clinton C. Howard, Atlanta, Ga.

A Critical Analysis of Gnathostatics in Orthodontia.—Abraham Wolfson, East Orange, N. J.

Mental Orthodontia—Its Stimulants and Depressants.—Russell E. Irish, Pittsburgh, Pa.

Orthodontia of Deciduous Teeth.—Albert C. Holzman, Boston, Mass.

Comparative Anatomy.—Herbert I. Margolis, Boston, Mass.

A Review of the Literature Pertaining to the Influence of Habits in Orthodontia.—Moe B. Markus, Philadelphia, Pa.

Physical Consideration Concerning the Alleged Stability of Bone and Similar Structures.—Samuel E. Pond, University of Pennsylvania.

Two Examples of Basic Maldevelopment in the Denture.—Bernard L. Hyams, Montreal.

A Study of Histologic Changes of the Bone as the Result of Tooth Movement in the Teeth of Dogs.—Martin Dewey, New York City.

The following series of Lectures will be given by Dr. Homer B. Robison of Great Bend, Kansas:

Abnormal Muscle Functioning Its Effect on Orthodontic Treatment.

Human Types—Normal and Abnormal.

Endocrines—Their Effect on the Osseous, Genital and Mental Development and Its Relation to Orthodontics.

Some Erroneous Diagnoses of Acromegaly.

Clinics will be given by the following men:

Irving Spenadel	New York City
Paul Geoffrion	Montreal
A. V. Greenstein	New York City
Harry E. Abelson	New York City
Bereu Fischer	New York City
Harry A. Holder	Nashville, Tenn.

A more complete program will be issued at a later date.

Paul G. Spencer, Pres.
Waco, Texas

Harry A. Holder, Secy.
Nashville, Tenn.

Walter E. Lipscomb, D.D.S., announces his return from a year spent in graduate study at the University of Pennsylvania with Dr. A. LeRoy Johnson and the removal of his offices to 1216-17 Medical Arts Building, Houston, Texas. Associated with Dr. Louis S. Winston. Practice limited to orthodontia exclusively.